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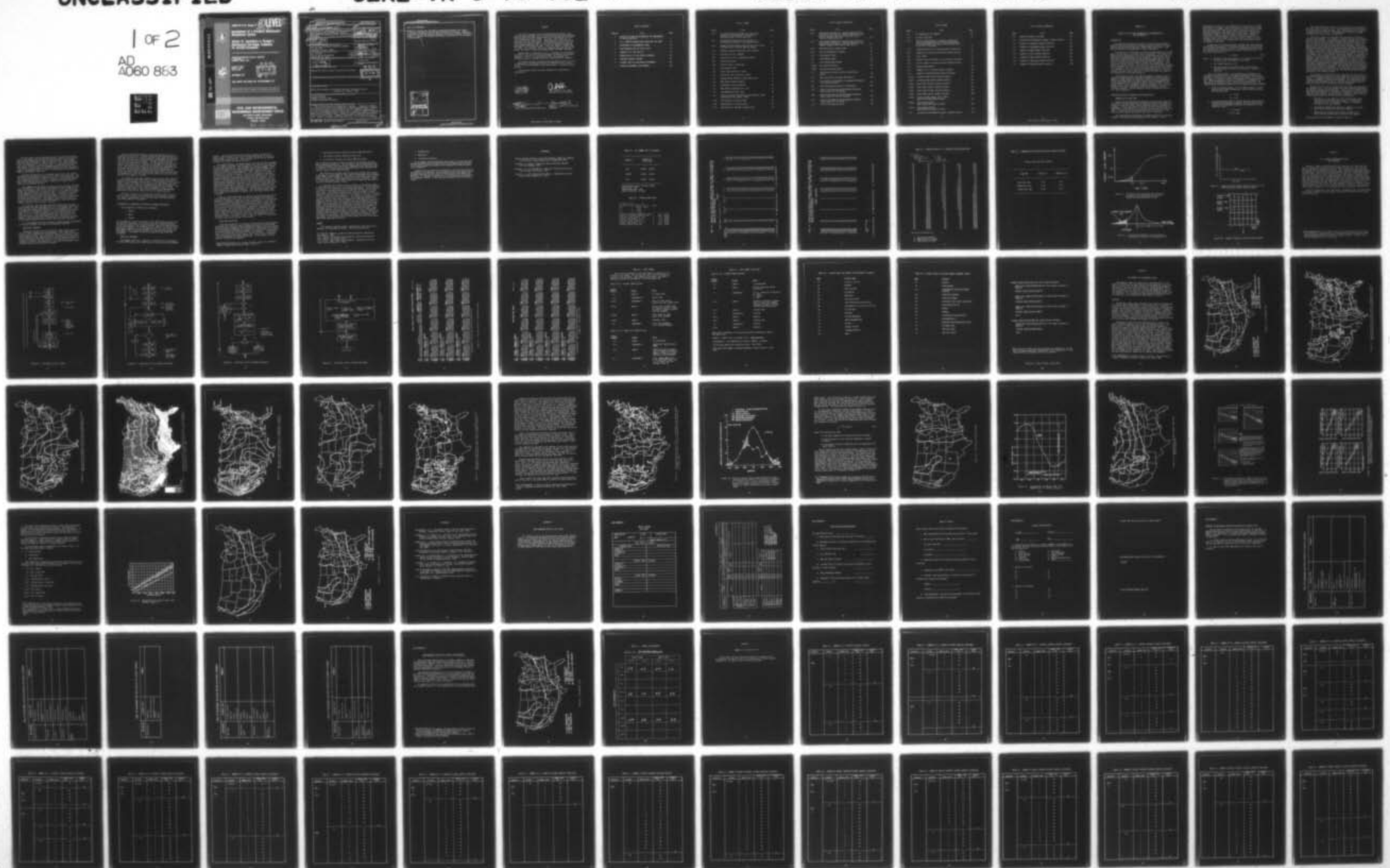

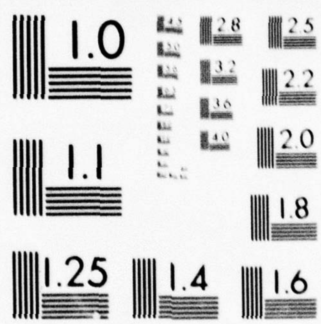

MICROCOPY RESOLUTION TEST CHART

CEEDO-TR-77-44, Volume IV

Development of a Pavement Maintenance Management System

Volume IV: Appendices A Through I, Maintenance and Repair Guidelines for Airfield Pavements

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CIVIL AND ENVIRONMENTAL ENGINEERING DEVELOPMENT OFFICE

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This volume presents the Appendices A through I. Appendix A contains the feasibility study of the consequences of maintenance and repair. Appendix B is an input guide to and flow chart of the PCI-1 computer program which calculates the pavement condition index (PCI). Appendix C contains the development of the environmental zones. Appendix D shows the questionnaires used on visits to Air Force bases. Appendix E summarizes all PCI data collected in FY77. Appendix F presents the correlation study of PCI and profile roughness. Cont

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Cont' Appendix G contains the information concerning maintenance and repair of features presented to the engineers attending the workshop. Appendix H describes an economic analysis procedure considering pavement performance. Appendix I contains the weighted performance questionnaires also presented at the workshop.

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PREFACE

This report documents work performed during the period 1 July 1976 through 30 September 1977 by the US Army Construction Engineering Research Laboratory under Project Order No 77-014 from the Air Force Civil Engineering Center (AFCEC). On 8 April 1977, AFCEC was reorganized into two organizations. AFCEC became part of the Air Force Engineering and Services Agency. The R&D function remains under Air Force Systems Command as Det 1 (Civil and Environmental Engineering Development Office-CEEDO) HQ ADTC. Both units remain at Tyndall AFB FL 32403. This technical report was completed under the auspices of CEEDO. Mr Donald N. Brown was program manager for AFCEC and CEEDO.

Appreciation is expressed to Dr S. H. Carpenter of the University of Illinois, who assisted in the development of Appendix A and wrote Appendix C, and Dr P. N. Sonnenburg of CERL, who performed the correlation study on pavement condition index and profile roughness.

This report has been reviewed by the Information Officer (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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APPENDIX A

FEASIBILITY STUDY FOR DETERMINING THE CONSEQUENCES OF M&R ALTERNATIVES

INTRODUCTION

This appendix presents the results of a feasibility study which examined the possible methods for predicting the occurrence of distress when various maintenance and repair (M&R) methods are applied. Some feasible methods are recommended for future development.

The importance of being able to predict the deterioration of a pavement with time arises in planning future maintenance. The difficulty of predicting the deterioration over time is compounded when the effect of applying various M&R methods must be considered. When distress occurrence can be predicted with and without M&R, pavement condition index (PCI) time curves can be constructed for various M&R strategies. The results of applying different M&R strategies can be predicted. These predictions provide the basis for calculating the effectiveness of different maintenance policies in maintaining a suitable level of performance over the design life. This ability to predict the distress occurrence in a pavement as a function of time and maintenance policy is the first and most necessary step in obtaining a logical procedure for comparing the economics of various M&R strategies.

The following sections describe the methods of predicting the consequences of M&R strategies which were considered for further study. Several of these methods are examined in detail and are recommended for further development when the results appear easily implementable and can be obtained with an acceptable amount of research effort. An important factor in the development of these procedures is the ability to determine the effects produced by different environment regions on distress occurrence. The environmental regions referred to herein are described in Appendix C.

PREDICTING DISTRESS OCCURRENCE WITH NO M&R APPLIED

PROBABILISTIC PREDICTIONS

When a pavement receives no maintenance, distress first appears as low severity and then progresses to medium and high severity under the effects of time and traffic. When a condition survey is performed on a pavement, the level and amount of distress for each distress type are determined. These quantities are used to calculate the PCI of the pavement. If these quantities could be predicted as a function of time, the PCI value could be predicted for any time in the future.

The development and progression of pavement distress is relatively unknown. Its occurrence and progression must, however, follow a

distribution of some form. For simplicity in this analysis, a normal distribution is assumed. Other distributions, however, may be chosen and may even be intermixed for any given distress type based on field tests and validation. The distress data collected at a given time represent one point on the normal distribution curve. Consider the data shown in Table A-1 for "D" cracking, taken from a condition survey of an airfield pavement in 1977. The total distress in "D" cracking covers 13.44 percent of the slabs after 35 years of service. The amount of distress will increase with time and eventually cover 100 percent of the slabs.

Assuming the "D" cracking distress increases over time according to the normal distribution, the following procedure can be used to predict the amount of distress. Figure A-1 illustrates how the distress will increase with time following the normal distribution curve. The statistical equation used is:

$$Z = (U-t)/\sigma \qquad \text{(A-1)}$$

where: U = the mean of the distribution, i.e., the time at which the distress occurs on 50 percent of the slabs,

σ = the standard deviation, and

t = the time elapsed since construction to the time the condition survey is taken or a percentage of distress is specified.

The initial datum needed in the probabilistic procedure is an estimate of distress-free life of pavement immediately following construction. During the first year that distress appears, an arbitrarily small amount of distress, typically 0.01 percent, is assumed to be present. These two quantities allow the statistics of the distress appearance to be predicted using a normal distribution function. Two steps should be followed to obtain a curve of the total distress present:

1. Using the two percentages, p_1 = 0.01 percent and p_f = 13.44 percent, obtain the corresponding Z values from the standard distribution tables.

$$Z_1 = 3.775$$

$$Z_f = 1.105$$

2. Using the selected times of 35 years (when the survey was conducted) and an estimate of distress-free life after 20 years, construct two simultaneous equations for Equation (A-1) and solve for σ and U.

$$\sigma = 5.6 \text{ years}$$

$$U = 41.2 \text{ years}$$

These calculations show that if "D" cracking covers 13.44 percent of the total slabs at 35 years, it will cover 50 percent after 41.2 years. At the end of 82.4 (twice the mean) years, 100 percent of the slabs will be covered with "D" cracking. This progression is shown as a normal cumulative distribution curve in Figure A-2.

The curve in Figure A-2 represents the total amount of distress present on the pavement. This amount is actually the sum of low, medium, and high level severity, and the procedure used to predict this curve does not indicate relative amounts of each severity level present. The data in Table A-1 show that at the time of the condition survey, 8.82 percent of the total area exhibited low severity distress, 4.2 percent showed medium severity distress, and 0.42 percent exhibited high severity distress. A field questionnaire (Appendix D) has been used in an attempt to determine the range of time periods involved for a given distress type to progress from low to medium and medium to high severity in a given environmental zone. More responses are needed, however, so that the time periods for each environmental zone and distress type will become more complete. The time periods influence the amount of a specific distress severity present at any time of the pavement life. A range in time periods can be used to obtain the best comparison with the actual distress data collected during the condition survey through trial and error of different combinations of expected time periods for low to medium and medium to high distress progression. The time periods used to calculate the distress present for each year are the ones that produce the values that provide the closest match with the low, medium, and high distress determined in the condition survey.

The procedure to determine the best combination of time periods is an iterative procedure involving a large number of trial and error calculations. A computer program has been prepared that allows these calculations to be made very rapidly and accurately. The following calculations have been performed on the "D" cracking data present earlier in Table A-1 and serve to illustrate the overall procedure.

When the data for the "D" cracking have been input into the program, the variables (i.e., the time periods) for initial distress appearance and distress progression must be input. These values are highly variable and open to each engineer's interpretation. Ranges for these values are input into the program to account for this variability. The following time periods are used for the calculations presented here:

1. Distress will first appear no earlier than 18 years after construction and no later than 22 years. An arbitrarily selected value of 0.01 percent of distress is assumed to be present at the time selected.

2. Low severity distress will progress to medium 2 to 5 years after the low severity distress first appears.

3. Medium severity distress will progress to high 4 to 6 years after the medium severity distress first appears.

The input data for this example are given in Table A-2.

The first step in the calculation process is to calculate the percent of low, medium, and high severity distress present at 35 years for every possible combination of the time periods given. Sample output from the computer program is given in Table A-3. The root-sum-squares error is an indicator of the relative error in comparing the calculated low, medium, and high severity percentages with the observed values. This value is used to select the optimum combination of the time period values. The optimum values for the "D" cracking data being analyzed are shown at the bottom of Table A-3.

Following the selection of the optimum time periods, the program calculates the percentage of each distress severity for every year. The "D" cracking calculations are shown in Table A-4. The program calculates this information and prints a table listing the distress present every year of the selected analysis period. Prediction of other distress types can be performed similarly.

This computer program offers the unique ability to analyze the same data in several ways. The analysis presented here used a normal distribution and range of values for the time periods. This combination represents the simplest way to analyze the data. If the normal distribution is not adequate, another distribution--such as the gamma or log-normal distribution--can be inserted into the program. This would allow a particular distribution to be used with particular distress types known to follow that distribution. For example, since fatigue cracking in asphalt concrete follows log-normal distributions, such distributions could be specified for this type of distress.

The assumption that the time period for distress severity level change remains the same throughout the life of the pavement might not be true; the time periods could actually vary as the pavement ages. This is schematically depicted in Figure A-3. At the beginning of the pavement's life, it is sound and change in distress severity might take longer to occur. As the pavement becomes older, deterioration will occur more rapidly since the pavement will have lost some of its integrity. These variations can be substituted into the proper position in the computer program without altering the calculation procedure.

It is recommended that the preliminary computer program incorporating all the above concepts be further investigated and developed.

ANALYTICAL PROCEDURE

Structural distress such as cracking and corner breaks relate directly to traffic loadings and fatigue damage. Thus, these forms of distress can be predicted on a mechanistic basis using the traffic level and structural section. Where analytical procedures exist that allow stress predictions, the amount of cracking can be predicted knowing the fatigue relationships for that material. The applicability of this procedure is shown in the prediction of load cracking performed on data collected from an airfield concrete pavement.

Using a normal distribution in the landing pattern of the predominant aircraft (DC-9), a probable number of edge loadings were computed for the central six slabs of concrete runway shown in Figure A-4. The stress caused by each load application was computed based on the slab thickness and subgrade support. Through the use of fatigue analysis the probability of failure, i.e., percentage slabs with load cracking, was predicted as a function of the number of load applications. The load cracking present in the pavement was determined from the condition survey and is compared with the calculated data in Table A-5. Both the predicted and actual values indicate that the central two slabs, which receive most load applications, have the highest percentage of slabs with load cracking, while the outer two slabs have the least amount of cracking.

This prediction technique, however, gives only the total amount of distress present and does not provide information about the relative amounts of the different severity levels. To obtain data on the severity levels present, the number of load applications that would cause the cracking to progress from low to medium to high must be estimated. This estimate is then used to predict the percentage of slabs with low, medium, and high severity load cracking following the same approach described in the previous section for the "D" cracking example.

The major limitation to the analytical method is that it can be used only where stresses can be predicted for the pavement structure. This leaves a large amount of distress that must still be predicted using the probabilistic procedure.

DETERMINING THE CONSEQUENCE OF APPLYING DIFFERENT M&R METHODS

Three categories of M&R must be considered:

1. Routine
2. Major
3. Overall.

The consequences of applying routine or major M&R can be predicted using the procedures presented in the previous section, although some modifications are necessary to include the effect the various M&R strategies have on the pavement. The following sections address the problem of predicting the consequence of overall M&R, which differs from routine and major M&R in that it typically upgrades the load-carrying capacity of the pavement. The methods discussed are analytical and field data collection.

ANALYTICAL PROCEDURE

The pavement condition is important in determining the consequence of overall M&R because overall M&R typically involves the entire pavement

surface. The more deteriorated the existing pavement, the lower its support value is likely to be, and the thicker the overlay is likely to be to provide a given service. Thus, the lower the PCI of the original pavement, the thicker the overlay should be.

The gradual decrease in pavement support over time has been accounted for in a number of overlay design procedures that typically use some form of deflection measurements. The procedure for flexible pavement overlay, recently developed for the Federal Highway Administration (FHWA), recognizes that increases in the amount of alligator cracking reduce the support value of the original pavement.[1] This results in a thicker overlay when more cracking is present. The Corps of Engineers' procedure for overlay design uses a correction factor that depends on the existing pavement condition to determine the required overlay thickness. By relating or substituting for the correction factor with the PCI, the procedure used in determining the PCI will have a direct application in the overlay design procedure. Therefore, if the loss in PCI over time can be predicted from present PCI data, the overlay thickness necessary at any time in the future can be predicted. This combination of the PCI and analytical overlay design procedures will indicate when an overlay should be considered over other M&R strategies. The procedure does not, however, predict the occurrence of distress after the overall M&R overlay is applied.

After an overall M&R overlay is applied, the problem becomes one of predicting how long it will take for cracking present in the original pavement to propagate through the overlay. One method that could be used for predicting distress appearance is fracture mechanics. Each type of crack (logitudinal, transverse, alligator, block, corner breaks, and joints) will produce different stress concentrations in an overlay that are a function of load and temperature. Because of the different stress concentrations, each crack type will propagate at a different rate and the distresses will appear at the surface of the overlay at different times. Under similar conditions the effect of overlay thickness can be studied directly. This analysis covers only the reappearance of old structural distress involving cracks; it does not predict the appearance of new distress on the surface of the overlay.

FIELD DATA COLLECTION

Field data collection is one means of obtaining data relating to the occurrence of all distress types following application of overall M&R. These data would ultimately allow formulation of models that would predict the total distress appearance on the surface of the overlay as a function of the condition of the original pavement. One method of obtaining such data is by conducting field surveys of various pavements. A long-term field survey of PCI data would provide a data base capable of determining the consequences of various M&R methods. In this study, PCI data would be collected from pavements:

[1]Asphalt Concrete Overlays of Flexible Pavements, Report No. FHWA-RD-76 (Federal Highway Administration [FHWA], June 1975).

1. That have previously received an overall M&R application;

2. Just before an overall M&R application; and

3. At intervals following the overall M&R application.

Data collected would also include the traffic, the pavement thickness, and the material properties. This information would be analyzed to see if certain variables alter the distress appearance more than others and to establish a universal equation for predicting the PCI variation with time for various overall M&R strategies.

The collection of distress and PCI data would require many surveys to be made at a large number of bases that have performed or will perform overall M&R on their pavements. To provide a significant number of data points for analysis, a large amount of data must be collected in order to insure that enough overall M&R methods are included that have been in place for different periods in time.

If long-term field surveys are not possible, an alternative method of data collection would be to distribute questionnaires to base engineers to determine their experiences with various M&R methods. The analysis of questionnaire responses would be more difficult than analysis of field survey data. The responses concerning an expected outcome of an M&R application that are to be combined into a uniform decision making process involve uncertainties and intangibles. The method of analyzing such data is known as Bayesian decision theory.[2,3] The underlying assumption in Bayesian theory is that events (consequences of M&R application) do not happen in isolation; thus, given certain positive information about the probability of one event, the probability of another event can be determined. Correct application of the Bayesian approach requires that the problem be systematically described before the subjective judgments of the experts can be identified and their preferences quantified. Using the Delphi Method,[4] the individuals' preferences can be collected and refined through controlled feedback of the group's overall response; this stimulates the individuals into making even better responses in suceeding rounds of questioning. The analysis must be very carefully done, but answers can be obtained with a minimal number of field visits, which makes these techniques attractive.

SUMMARY

This appendix presented various procedures for predicting the consequences of various M&R strategies. These alternatives were:

[2] R. Schlaifer, Analysis of Decision Under Uncertainty (McGraw-Hill Book Company, 1969).
[3] R.L., Winkler, An Introduction to Bayesian Influence and Decision (Holt Reinhart and Winston, 1972).
[4] B.A., Fisher, Small Group Decision-Making: Communication and The Group Process (McGraw-Hill, 1974).

1. Probabilistic

2. Analytical

3. Field data collection.

It is evident that the long-term field surveys to collect PCI data and M&R information would provide the data base necessary for determining a universal equation to predict the consequences of M&R activities in all categories.

Probabilistic and analytical procedures do exist that allow distress occurrences to be predicted. These procedures allow some comparisons to be made without waiting the length of time necessary to establish the data base. To validate the predictions of the analytical and probabilistic procedures, however, a data base would eventually have to be established.

REFERENCES

Asphalt Concrete Overlays of Flexible Pavements, Report No. FHWA-RD-75-76 (Federal Highway Administration [FHWA], June 1975).

Schlaifer, R., Analysis of Decision Under Uncertainty (McGraw-Hill Book Company, 1969).

Winkler, R. L., An Introduction to Bayesian Inference and Decision (Holt Reinhart and Winston, 1972).

Fisher, B. A., Small Group Decision-Making: Communication and The Group Process (McGraw-Hill, 1974).

TABLE A-1. PCI SUMMARY FOR "D" CRACKING

SEVERITY	PERCENT OF TOTAL SLABS	
LOW	0.0882	(8.82%)
MEDIUM	0.0420	(4.20%)
HIGH	0.0042	(0.42%)

Total distress slabs = 0.1344 (13.44%)
Survey Date: 1977
Construction Date: 1942
Years in Service: 35 Years

TABLE A-2. DISTRESS INPUT DATA

```
DISTRESS TYPE =        4.
% DISTRESS AT INITIAL TIME =    .0100
AGE            =     35.00   YEARS
% L            =      8.82
% M            =      4.20
% H            =       .42
EARLIEST DISTRESS STARTING TIME =     18.0   YEARS
LATEST DISTRESS STARTING TIME   =     22.0   YEARS
EARLIEST TIME FROM L TO M       =      2.0   YEARS
LATEST TIME FROM L TO M         =      5.0   YEARS
EARLIEST TIME FROM M TO H       =      4.0   YEARS
LATEST TIME FROM M TO H         =      6.0   YEARS
MAXIMUM PREDICTION AGE          =     70.0   YEARS
```

TABLE A-3. PORTION OF THE OUTPUT OF A COMPUTER PROGRAM THAT SHOWS THE DETERMINATION OF THE OPTIMUM COMBINATION OF STARTING TIMES, TIME FROM L TO M, AND TIME FROM M TO H FOR "D" CRACKING

EXAMPLE

ERROR SUMMARY FOR DISTRESS TYPE 4.

ROOT-SUM-SQUARES ERROR	YEAR START	TIME FROM L TO M	TIME FROM M TO H	% L+M+H	% L	% M	% H
3.8747	18	2	4	13.44	5.66	5.75	2.03
3.9747	18	2	5	13.44	5.66	6.41	1.38
4.1705	18	2	6	13.44	5.66	6.87	.91
1.4831	18	3	4	13.44	7.70	4.37	1.38
1.3783	18	3	5	13.44	7.70	4.83	.91
1.4818	18	3	6	13.44	7.70	5.15	.59
1.1789	18	4	4	13.44	9.29	3.24	.91
.8147	18	4	5	13.44	9.29	3.56	.59
.6373	18	4	6	13.44	9.29	3.77	.37
2.5145	18	5	4	13.44	10.51	2.34	.59
2.3538	18	5	5	13.44	10.51	2.56	.37
2.2644	18	5	6	13.44	10.51	2.70	.23
3.5311	19	2	4	13.44	5.94	5.74	1.76
3.6679	19	2	5	13.44	5.94	6.35	1.15
3.8704	19	2	6	13.44	5.94	6.77	.74
1.0786	19	3	4	13.44	8.03	4.26	1.15
.9752	19	3	5	13.44	8.03	4.68	.74
1.0926	19	3	6	13.44	8.03	4.95	.46
1.4202	19	4	4	13.44	9.63	3.08	.74
1.1716	19	4	5	13.44	9.63	3.35	.46
1.0580	19	4	6	13.44	9.63	3.53	.28
2.8552	19	5	4	13.44	10.82	2.16	.46
2.7334	19	5	5	13.44	10.82	2.34	.28
2.6662	19	5	6	13.44	10.82	2.46	.17
3.1643	20	2	4	13.44	6.25	5.70	1.49
3.3319	20	2	5	13.44	6.25	6.26	.94
3.5334	20	2	6	13.44	6.25	6.62	.57
.6801	20	3	4	13.44	8.39	4.12	.94
.5404	20	3	5	13.44	8.39	4.48	.57
.6780	20	3	6	13.44	8.39	4.71	.34
1.7630	20	4	4	13.44	9.98	2.88	.57
1.5919	20	4	5	13.44	9.98	3.12	.34
1.5122	20	4	6	13.44	9.98	3.26	.20
3.2262	20	5	4	13.44	11.14	1.96	.34

L - Low severity stress M - Medium severity stress H - High severity distress

TABLE A-3. PORTION OF THE OUTPUT OF A COMPUTER PROGRAM THAT SHOWS THE DETERMINATION OF THE OPTIMUM COMBINATION OF STARTING TIMES, TIME FROM L TO M, AND TIME FROM M TO H FOR "D" CRACKING

EXAMPLE (CONCLUDED)

3.1351	20	5	5	13.44	11.14	2.10	.20
3.0856	20	5	6	13.44	11.14	2.19	.11
2.7658	21	2	4	13.44	6.59	5.63	1.23
2.9558	21	2	5	13.44	6.59	6.12	.74
3.1483	21	2	6	13.44	6.59	6.42	.43
.4150	21	3	4	13.44	8.77	3.94	.74
.0660	21	3	5	13.44	8.77	4.24	.43
.2956	21	3	6	13.44	8.77	4.43	.24
2.1745	21	4	4	13.44	10.35	2.66	.43
2.0543	21	4	5	13.44	10.35	2.85	.24
1.9968	21	4	6	13.44	10.35	2.96	.13
3.6203	21	5	4	13.44	11.47	1.74	.24
3.5540	21	5	5	13.44	11.47	1.84	.13
3.5191	21	5	6	13.44	11.47	1.91	.07
2.3265	22	2	4	13.44	6.97	5.50	.97
2.5288	22	2	5	13.44	6.97	5.92	.55
2.7044	22	2	6	13.44	6.97	6.17	.30
.6285	22	3	4	13.44	9.18	3.71	.55
.4549	22	3	5	13.44	9.18	3.96	.30
.4600	22	3	6	13.44	9.18	4.10	.16
2.6366	22	4	4	13.44	10.74	2.40	.30
2.5520	22	4	5	13.44	10.74	2.54	.16
2.5114	22	4	6	13.44	10.74	2.62	.08
4.0288	22	5	4	13.44	11.79	1.49	.16
3.9828	22	5	5	13.44	11.79	1.57	.08
3.9597	22	5	6	13.44	11.79	1.61	.04

OPTIMUM VALUES

.0660	21	3	5

L - Low severity distress   M - Medium severity distress   H - High severity distress

TABLE A-4. COMPUTER OUTPUT OF "D" CRACKING DISTRESS PREDICTION

```
TRIAL VALUES
    INITIAL TIME         =     21.0  YEARS
    TIME FROM L TO M =          3  YEARS
    TIME FROM M TO H =          5  YEARS
        MEAN                  =    40.8009  YEARS
        STANDARD DEVIATION =     5.2454  YEARS
```

YEAR	% L+M+H	% L	% M	% H
21	.01	.01	0.00	0.00
22	.02	.02	0.00	0.00
23	.04	.04	0.00	0.00
24	.07	.06	.01	0.00
25	.13	.11	.02	0.00
26	.24	.20	.04	0.00
27	.43	.36	.07	0.00
28	.74	.60	.13	0.00
29	1.23	.98	.23	.01
30	1.98	1.55	.41	.02
31	3.09	2.35	.70	.04
32	4.67	3.45	1.16	.07
33	6.85	4.87	1.84	.13
34	9.74	6.65	2.85	.24
35	13.44	8.77	4.24	.43
36	18.01	11.15	6.12	.74
37	23.44	13.69	8.52	1.23
38	29.67	16.23	11.47	1.98
39	36.57	18.56	14.92	3.09
40	43.94	20.50	18.76	4.67
41	51.51	21.84	22.82	6.85
42	59.04	22.47	26.83	9.74
43	66.25	22.31	30.49	13.44
44	72.90	21.39	33.51	18.01
45	78.83	19.79	35.60	23.44
46	83.92	17.67	36.58	29.67
47	88.13	15.23	36.33	36.57
48	91.50	12.67	34.89	43.94
49	94.10	10.18	32.41	51.51
50	96.02	7.89	29.10	59.04
51	97.41	5.90	25.26	66.25
52	98.36	4.26	21.20	72.90
53	99.00	2.97	17.20	78.83
54	99.41	2.00	13.49	83.92
55	99.66	1.30	10.23	88.13
56	99.81	.81	7.49	91.50
57	99.90	.49	5.31	94.10
58	99.95	.29	3.63	96.02
59	99.97	.16	2.40	97.41
60	99.99	.09	1.54	98.36
61	99.99	.05	.95	99.00
62	100.00	.02	.57	99.41
63	100.00	.01	.33	99.66
64	100.00	.01	.18	99.81
65	100.00	.00	.10	99.90
66	100.00	.00	.05	99.95
67	100.00	.00	.03	99.97
68	100.00	.00	.01	99.99
69	100.00	.00	.01	99.99
70	100.00	.00	.00	100.00

END OF LOOP ON DISTRESS TYPE 4.

L - Low severity distress
M - Medium severity distress
H - High severity distress

TABLE A-5. COMPARISON OF PREDICTED AND ACTUAL CRACKING DISTRESS

Percent Slabs with Load Cracking

SLAB ROW	ACTUAL (%)	PREDICTED (%)
Outer two slabs	0.84	0.01
Middle two slabs	8.40	11.49
Central two slabs	31.09	30.12

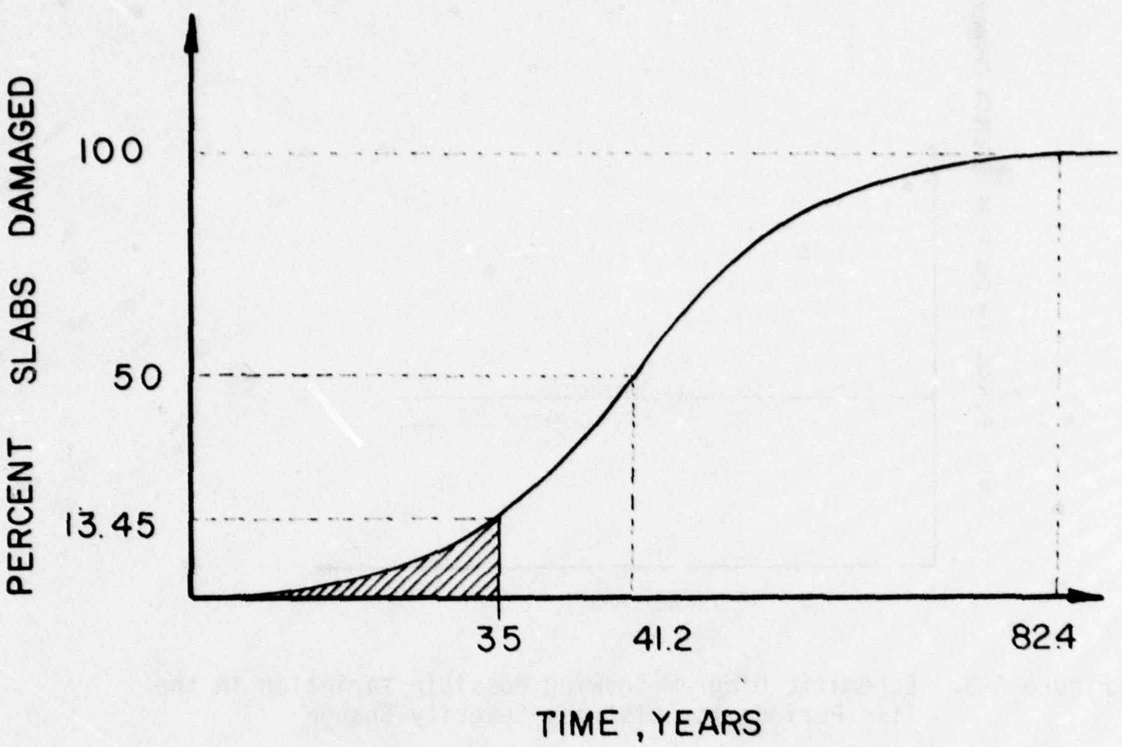

Figure A-1. "D" Cracking Data Calculated from Statistical Procedures, and Expressed in the Form of a Cumulative Normal Distribution Curve

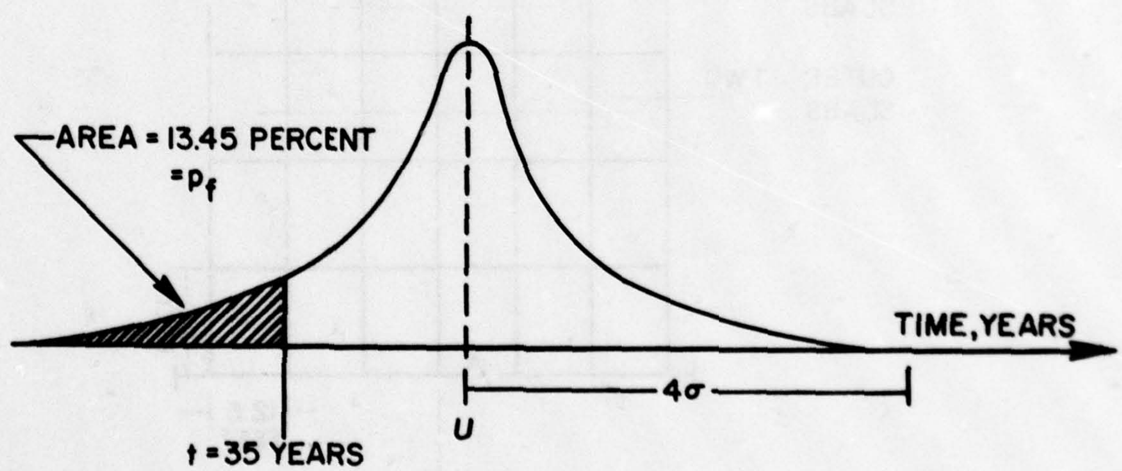

Figure A-2. The Normal Distribution Curve with the "D" Cracking Data Indicated in the Shaded Portion

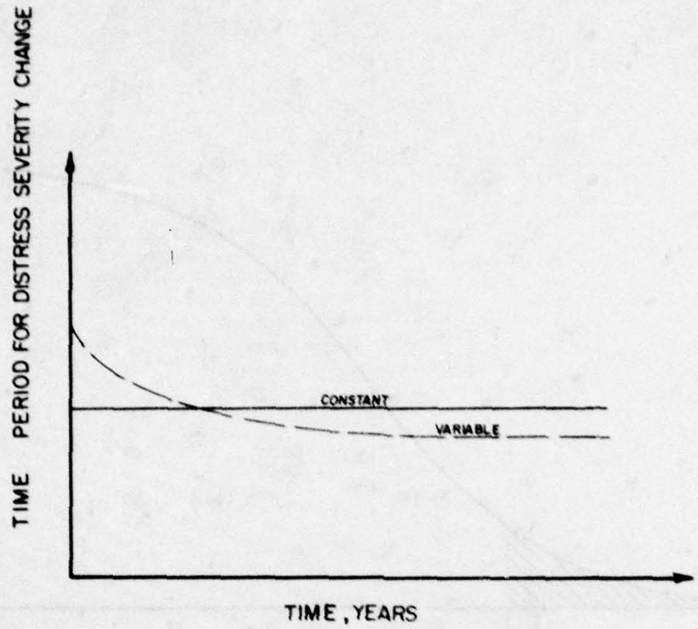

Figure A-3. Schematic Diagram Showing Possible Variation in the Time Periods for Distress Severity Change

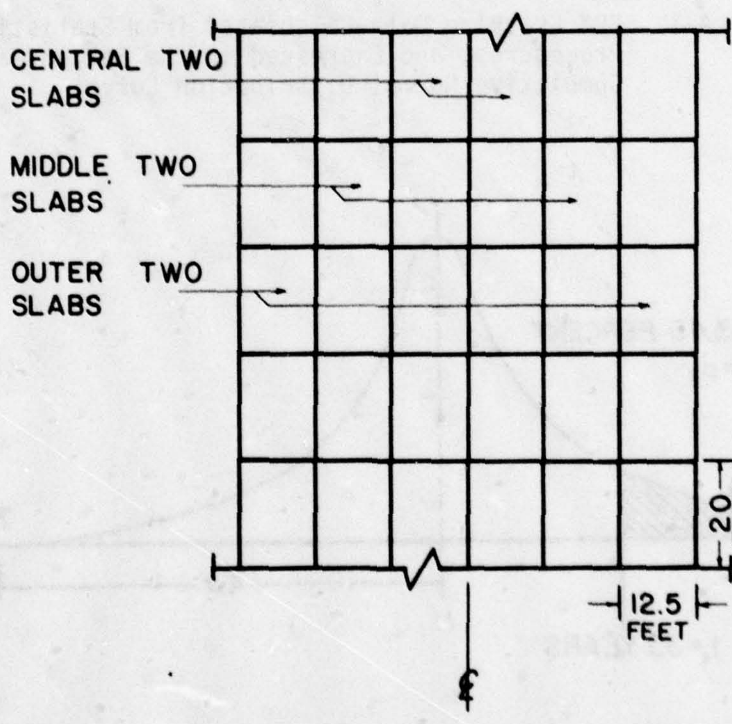

Figure A-4. Schematic Diagram of Concrete Slabs Surveyed

APPENDIX B

PCI-1 COMPUTER PROGRAM INPUT GUIDE AND FLOW CHART

Figure B-1 shows a flow chart of the PCI-1 program. The input forms for the PCI computation program are shown in Figures B-2 and B-3. Table B-1 presents guidelines for completing the forms. The information boxes on the forms are labeled with column numbers so that computer cards can be keypunched directly from the forms. Each line of information on the forms will produce one computer card. At the top of the first form, the name of the feature is entered, along with such information as the allowable error* in the estimate of the mean pavement condition index (PCI). The rest of the form is used to identify each sample unit surveyed and to enter the type, quantity, and severity of up to 18 distress/severity combinations for each sample unit. The second form (Figure B-3) is a continuation of the first form. As many continuation sheets as necessary may be used to record the inspection data for the feature. Tables B-2 and B-3 give distress codes for asphalt- or tar- surfaced and concrete pavements, respectively.

Once the information on the input forms is keypunched, the input deck should be arranged in exactly the same order as the lines of information on the input forms (Figure B-4).

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*The allowable error is the number of points the calculated PCI for an inspection performed by sampling may vary from the value the PCI would have if the inspection were performed on the entire pavement feature. A typical value for the allowable error is five points.

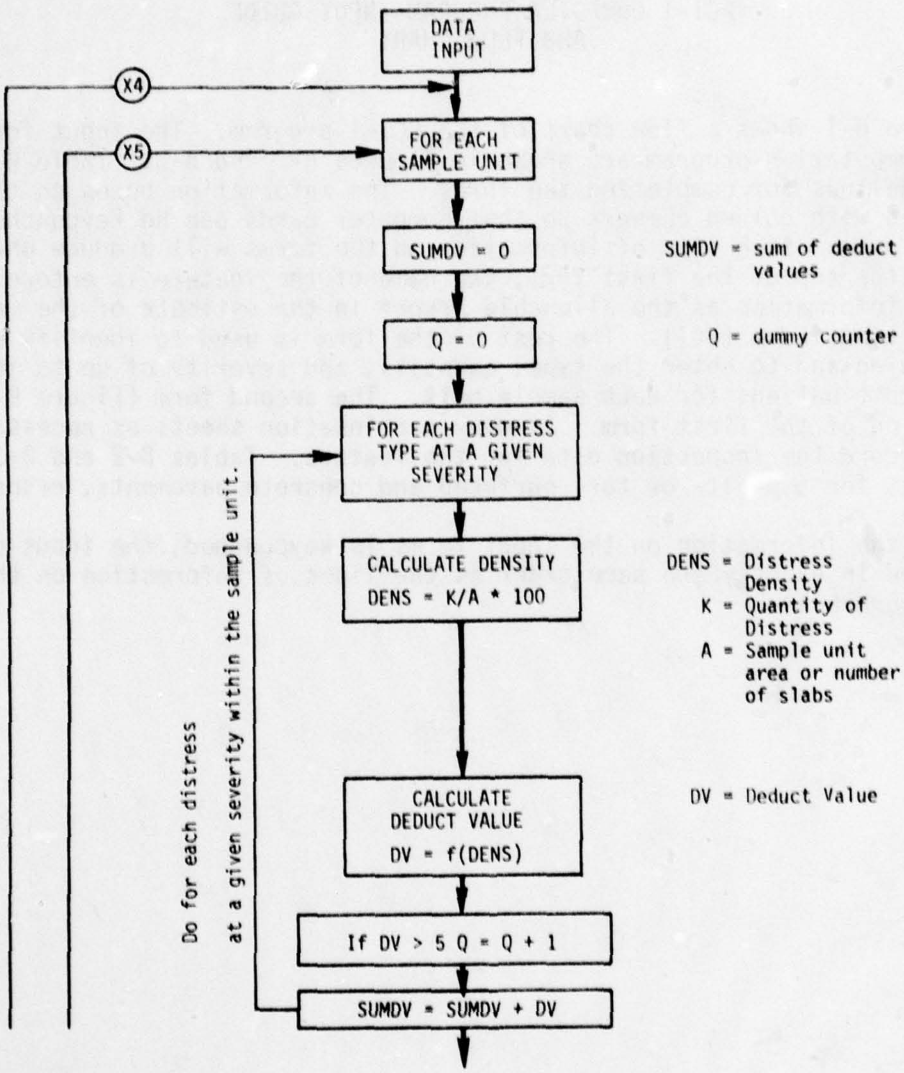

Figure B-1. Flow Chart of PCI-1 Program

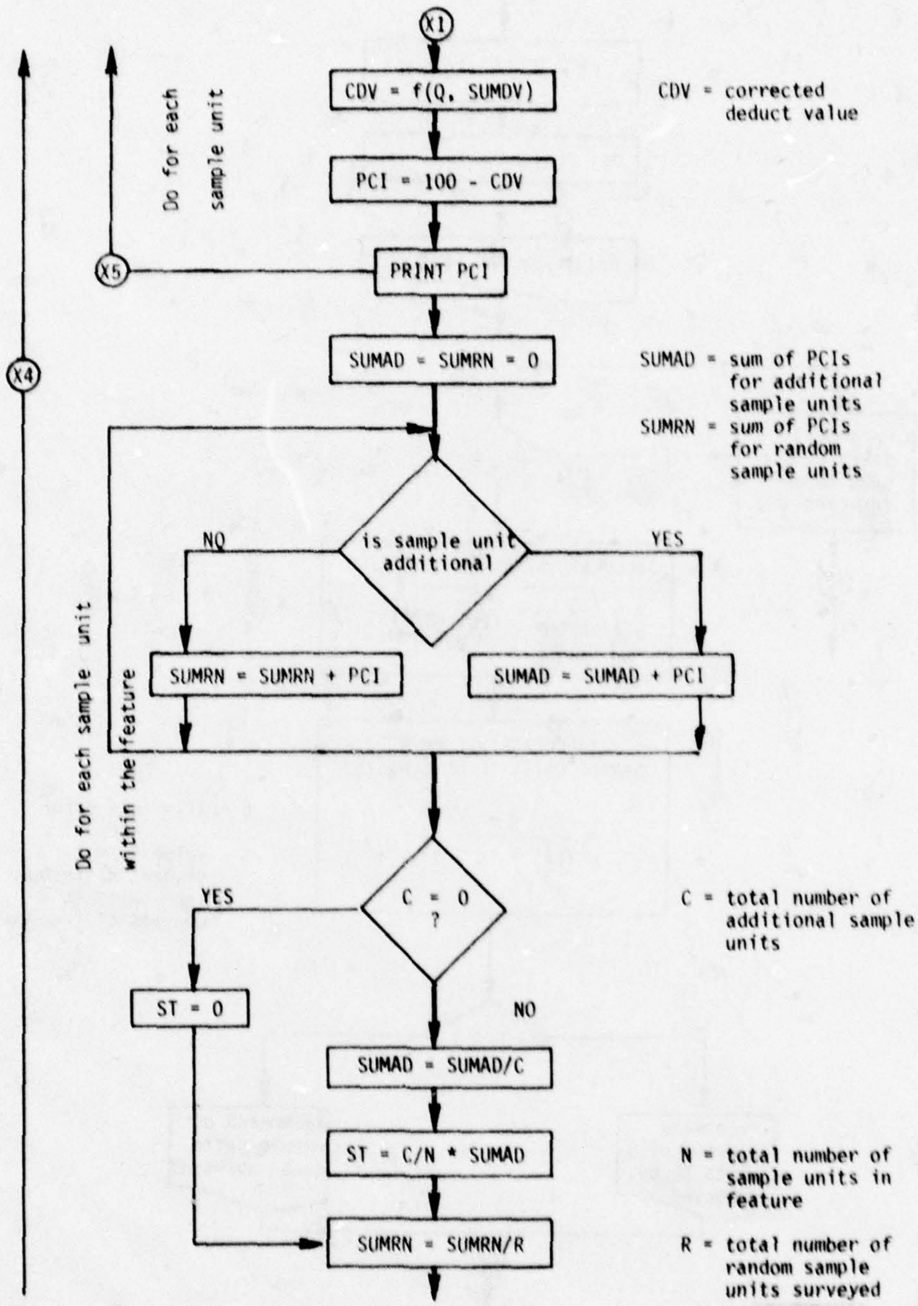

Figure B-1. Flow Chart of PCI-1 Program (Continued)

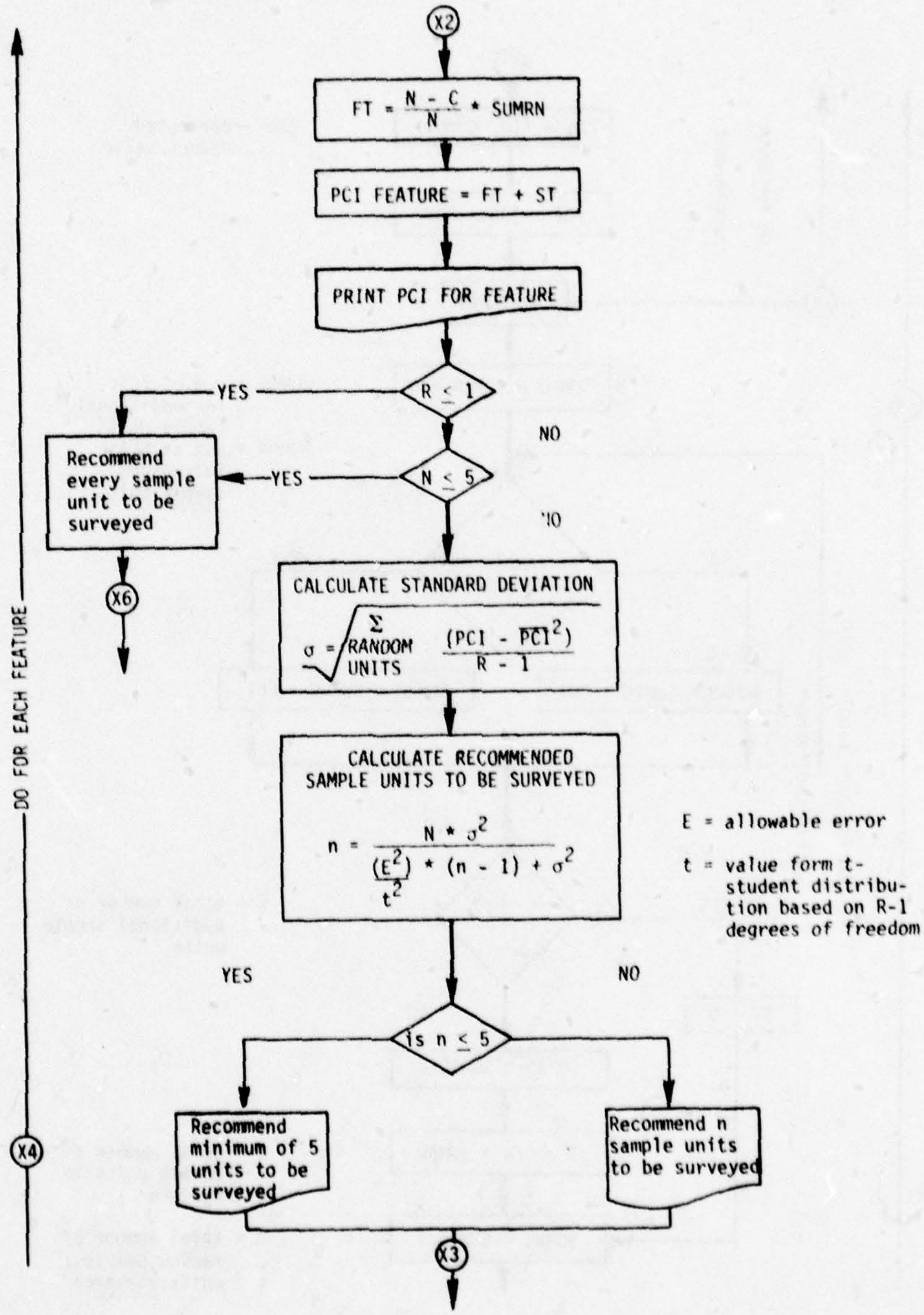

Figure B-1. Flow Chart of PCI-1 Program (Continued)

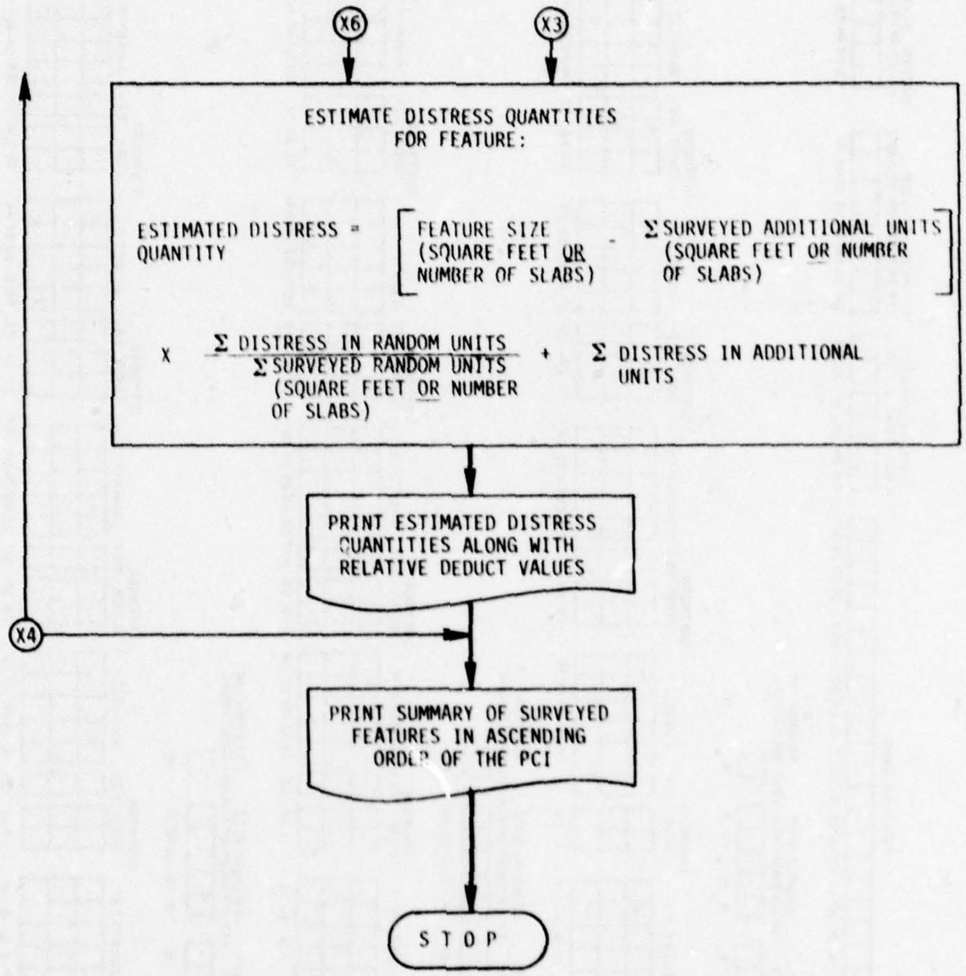

Figure B-1. Flow Chart of PCI-1 Program (Concluded)

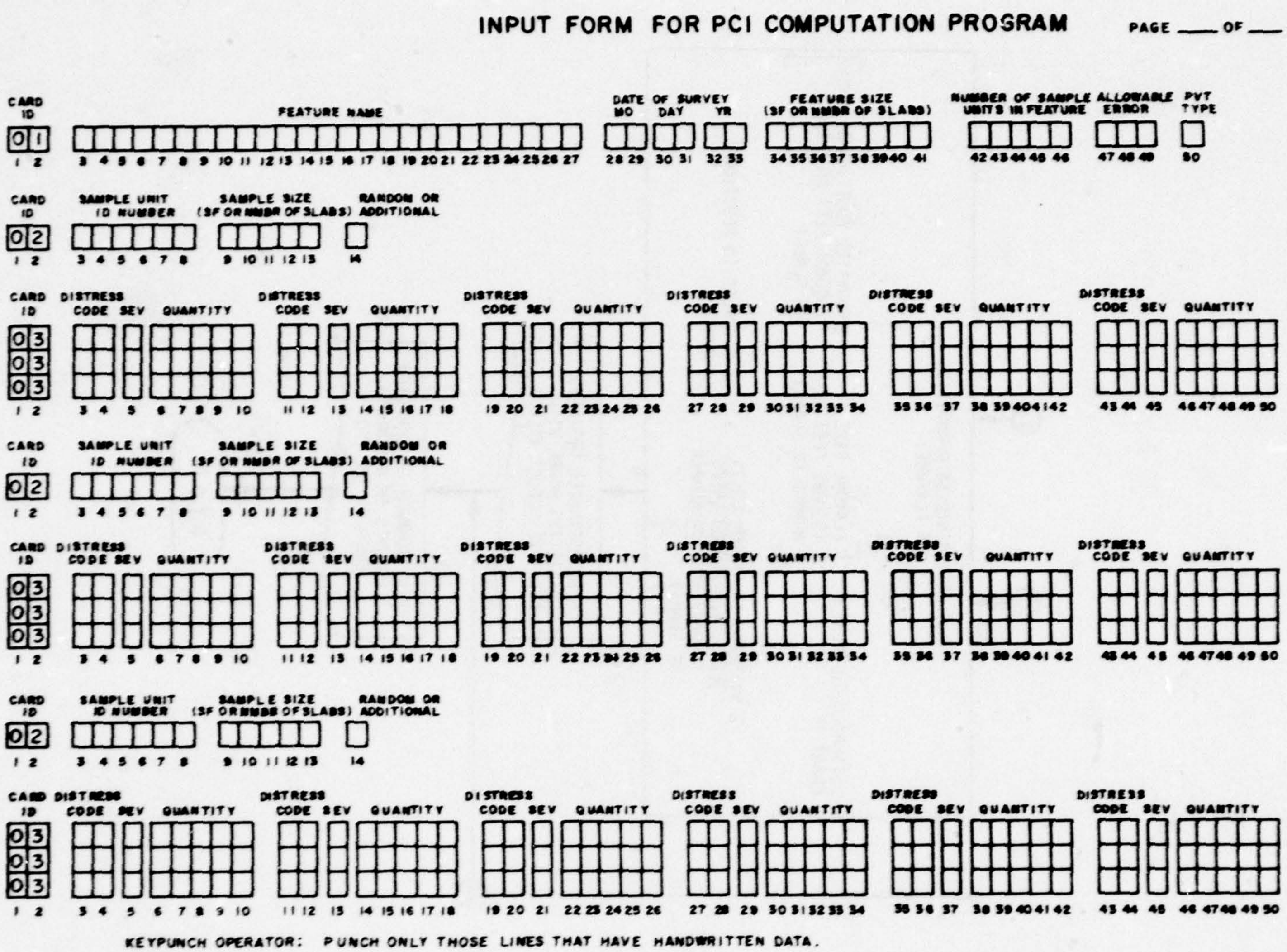

Figure B-2. Input Form for PCI-1 Computation Program

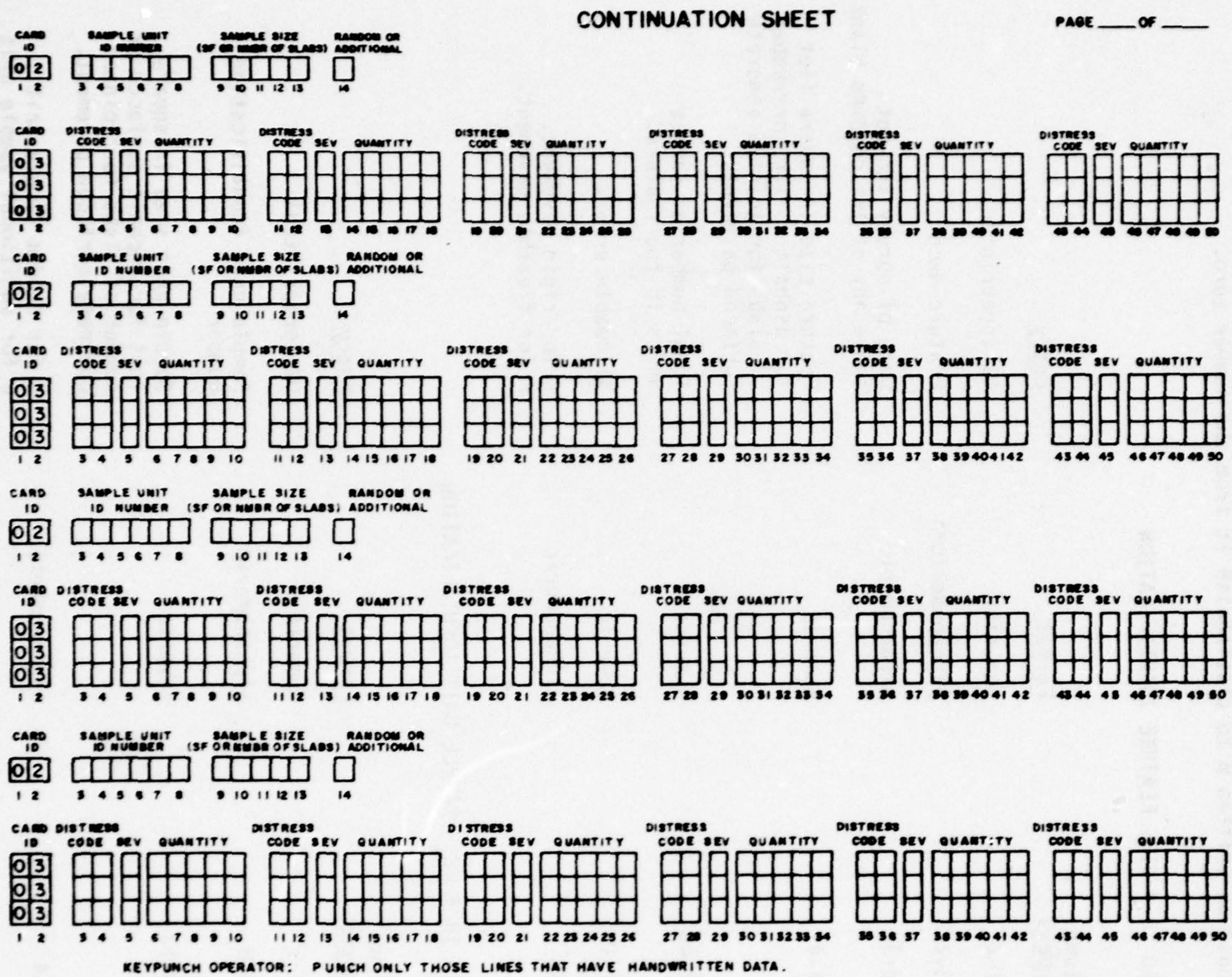

Figure B-3. Continuation Sheet

TABLE B-1. INPUT FORMAT

Each line of information on the input forms is preceded by a preprinted card ID number. The instructions that follow are grouped according to card ID number. When completing the forms, the letter O should be written Ø to distinguish it from the number zero.

CARD ID # 01 - FEATURE IDENTIFICATION

Column Numbers	Format	Entry
1-2	numeric*	01 (preprinted)
3-27	alphanumeric**	Feature Name
28-33	alphanumeric	Date of survey (do not leave any of the columns blank)
34-41	numeric	Feature size in square feet for asphalt surface or number of slabs for jointed concrete surfaced pavement.
42-46	numeric	Total number of sample units in the feature.
47-49	numeric	Allowable error.
59	alphanumeric	R for rigid pavement. F for flexible pavement.

CARD ID # 02 - SAMPLE UNIT IDENTIFICATION

Column Numbers	Format	Entry
1-2	numeric	02 (preprinted)
3-8	alphanumeric	Sample unit identification number
9-13	numeric	Sample unit size in square feet for asphalt surfaced or number of slabs for jointed concrete surfaced pavement.
14	alphanumeric	R for random sample unit C for additional sample unit (if all sample units are surveyed, enter R)

TABLE B-1. INPUT FORMAT (CONCLUDED)

CARD ID # 03 - DISTRESS IDENTIFICATION

Column Numbers	Format	Entry
1-2	numeric	03 (preprinted)
3-4	numeric	Distress code (see Tables B-2 & B-3)
5	alphanumeric	H, M, L, (severity of distress)+ H = high M = medium L = low
6-10	numeric	Quantity of distress in square feet or linear feet (asphalt surfaced) or number of slabs (jointed concrete surface).++
11-12	numeric	Distress Code
13	alphanumeric	Severity
14-18	numeric	Quantity
19-20	numeric	Distress code
21	alphanumeric	Severity
22-26	numeric	Quantity

Repeat this information for distress type/severity combination found in the sample unit.

*numeric: numbers only, no decimal point. Right-justified.

**alphanumeric: any combination of letters, numbers, or symbols.

+For distress types with no severity levels, leave blank.

++For joint seal damage in concrete pavements (distress code 5), leave blank.

TABLE B-2. DISTRESS CODES FOR ASPHALT OR TAR SURFACES (FLEXIBLE)

Code	Distress Type
01	Alligator Cracking
02	Bleeding
03	Block Cracking
04	Corrugation
05	Depression
06	Jet Blast Erosion
07	Joint Reflection Cracking (PCC)
08	Longitudinal and Transverse Cracking
09	Oil Spillage
10	Patching
11	Polished Aggregate
12	Ravelling/Weathering
13	Rutting
14	Shoving from PCC
15	Slippage Cracking
16	Swell

TABLE B-3. DISTRESS CODES FOR JOINTED CONCRETE PAVEMENT (RIGID)

Code	Distress
01	Blow-Up
02	Corner Breaks
03	Longitudinal/Transverse/Diagonal Cracking
04	Durability Cracking
05	Joint Seal Damage
06	Patching of less than 5 square feet
07	Patching/Utility Cut
08	Popouts
09	Pumping
10	Scaling/Map Cracking/Crazing
11	Settlement/Fault
12	Shattered Slab/Intersecting Cracks
13	Shrinkage Crack
14	Spalling, Joint
15	Spalling, Corner

FEATURE IDENTIFICATION CARD (for first feature surveyed)

SAMPLE UNIT IDENTIFICATION CARD (for first sample surveyed in feature)

DISTRESS IDENTIFICATION CARD(S)[a]

SAMPLE UNIT IDENTIFICATION CARD (for second sample surveyed in feature)

DISTRESS IDENTIFICATION CARD(S)

SAMPLE UNIT IDENTIFICATION CARD (for third sample surveyed in feature)

DISTRESS IDENTIFICATION CARD(S)

(ETC.)

FEATURE IDENTIFICATION CARD (for second feature surveyed)

SAMPLE UNIT IDENTIFICATION CARD (for first sample surveyed in feature)

DISTRESS IDENTIFICATION CARD(S)

(ETC.)

[a]More than one of these cards may be entered here depending on the number of distress type/severity combinations in the sample unit. If the sample unit has no distress, this card is omitted.

Figure B-4. Order of Cards in Input Deck

APPENDIX C

DEVELOPMENT OF ENVIRONMENTAL ZONES

Environmental zones are established to indicate specific areas where the climate exerts approximately the same influence on the pavement structure or has the same potential for damaging the pavement. The two most important factors are moisture and temperature. The soil type also tends to vary the effect of these environmental factors on the pavement, since silt and clay soils perform differently under similar conditions. This appendix provides background information used in the selection of the environmental zones shown in Figure C-1.

MOISTURE

The two most common forms of moisture are rainfall and evaporation. The average annual precipitation for the United States is shown in Figure C-2, and the evaporation is shown in Figure C-3. The difference in these two quantities represents the moisture available to damage the pavement unless moisture is added from some other source. There are, however, other factors to consider. The first is transpiration of soil moisture by plants, which effectively removes soil moisture and returns it to the atmosphere. The second is moisture storage. A soil can accept only a limited quantity of moisture before the remaining moisture will run off and not influence the behavior of the soil.

Thornthwaite[1] used the factors mentioned above to predict the actual moisture condition in a soil over the period of a year. The major concept in combining these factors was the development of a calculation scheme for potential evapotranspiration. This quantity represents the theoretical maximum amount of moisture that could be drawn out of the soil by evaporation and transpiration, if there was an unlimited supply of water to the soil-plant system. This concept takes into account the climatic effects, soil type, and vegetation. The distribution of the potential evapotranspiration across the United States is given in Figure C-4, which indicates that the Southern and Western portions of the United States are capable of removing more moisture from the soil than other portions of the country. This is expected because these regions experience more sunshine and radiation and have a warmer mean annual temperature, all of which promote evaporation and transpiration. Figure C-5 shows the variation of sunshine, Figure C-6 shows the distribution of solar radiation, and Figure C-7 shows the distribution of the mean monthly temperature for July. These figures illustrate the areas where moisture removal may be expected to predominate.

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[1]C. W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," Geographical Review, Volume 38, pp. 55-97, 1948.

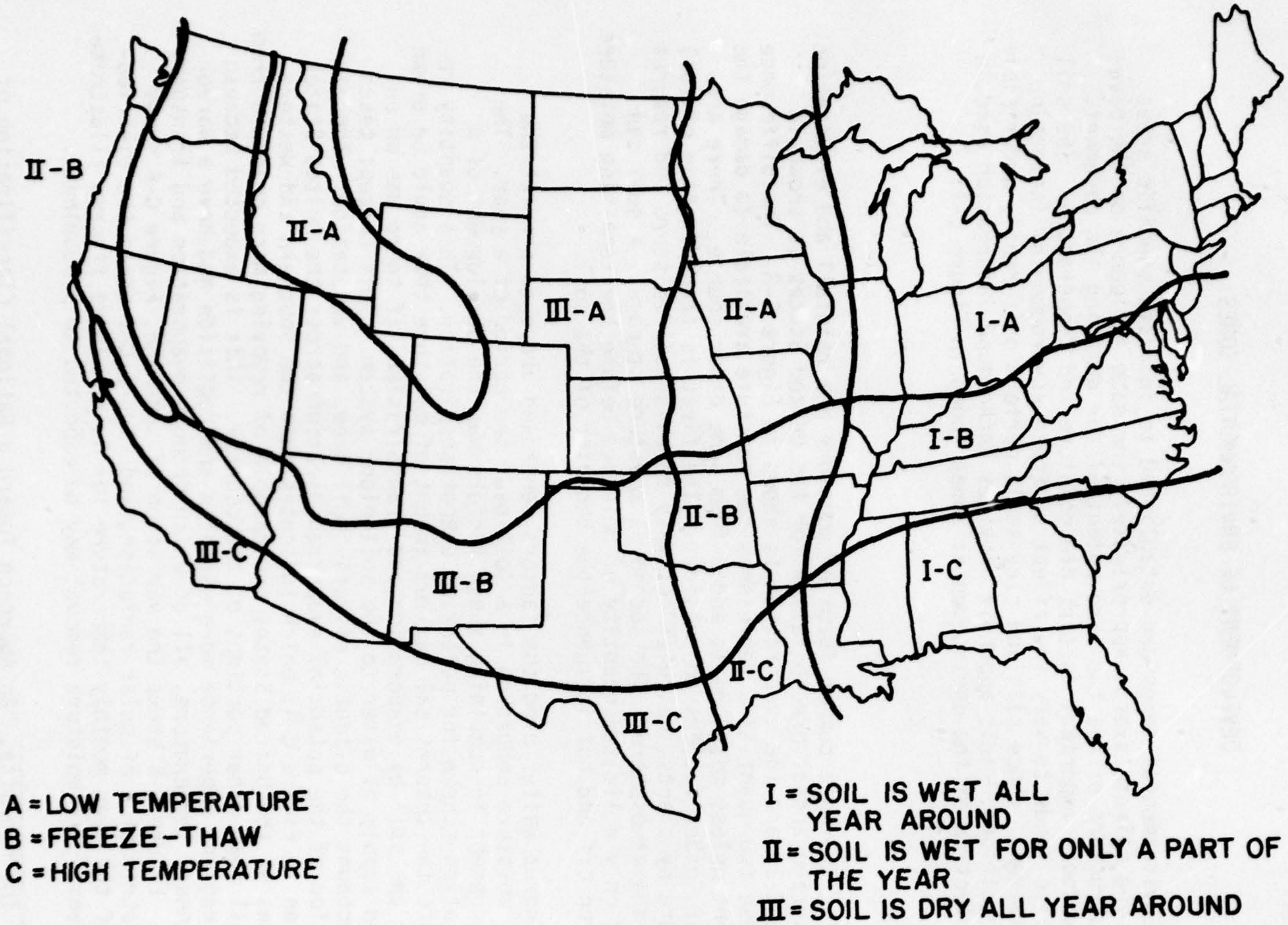

Figure C-1. Environmental Zones

Figure C-2. Annual Precipitation in Inches (From U.S. Department of Interior, Geological Survey, National Atlas of United States of America)

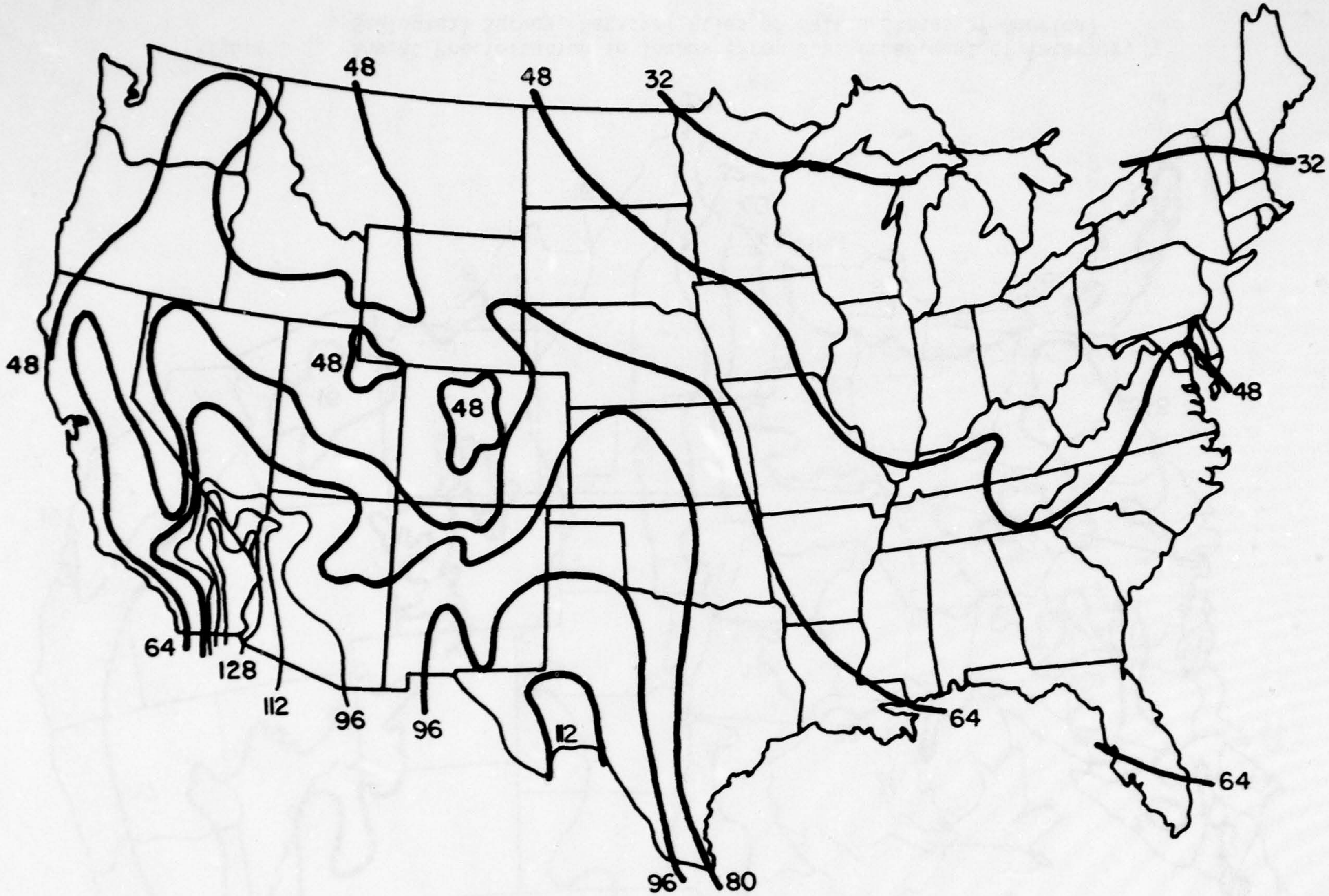

Figure C-3. Mean Annual Pan Evaporation, Inches (From U.S. Department of Interior, Geological Survey, National Atlas of United States of America)

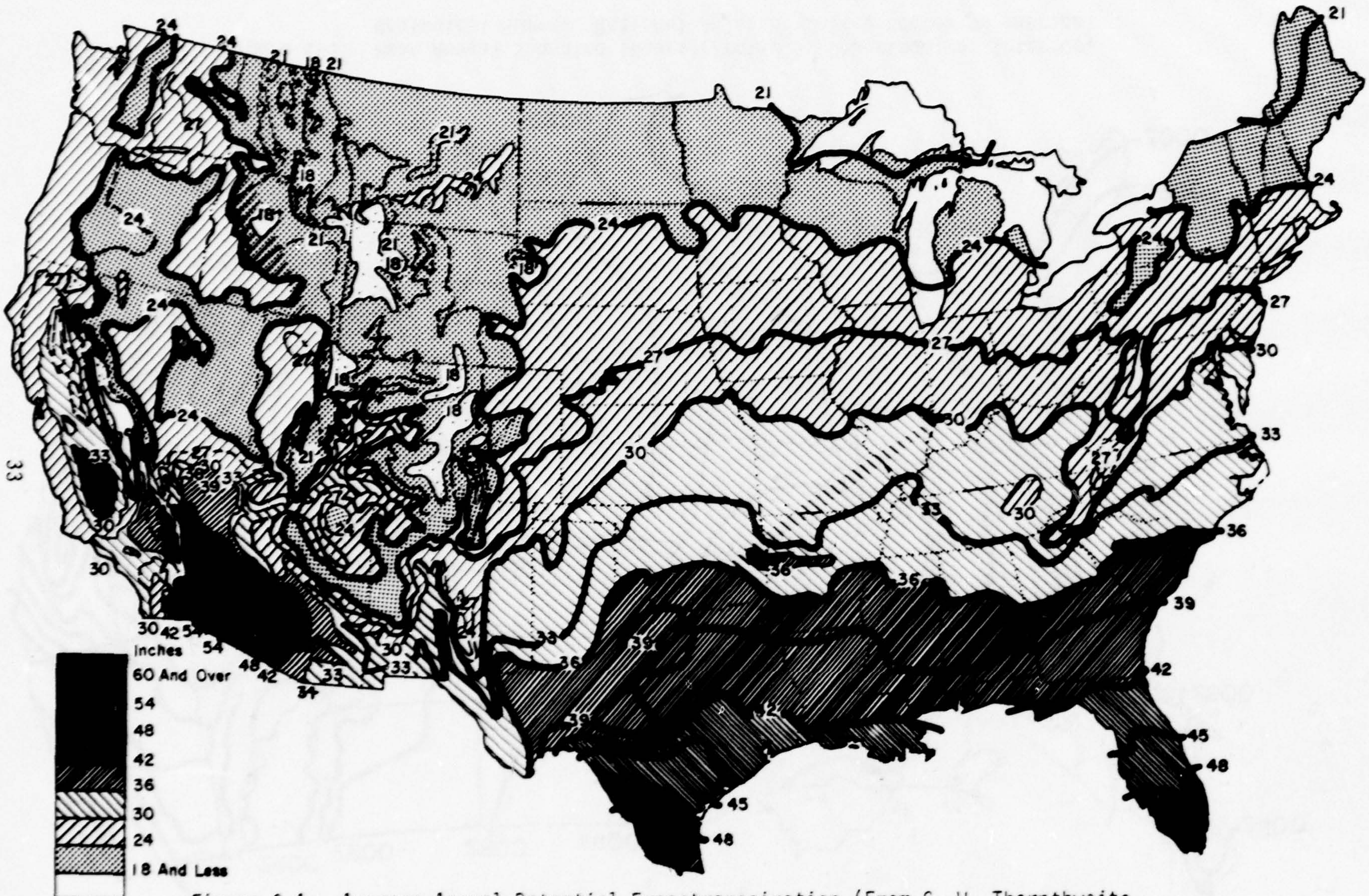

Figure C-4. Average Annual Potential Evapotranspiration (From C. W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," Geographical Review, Volume 38, pp. 55-97, 1948)

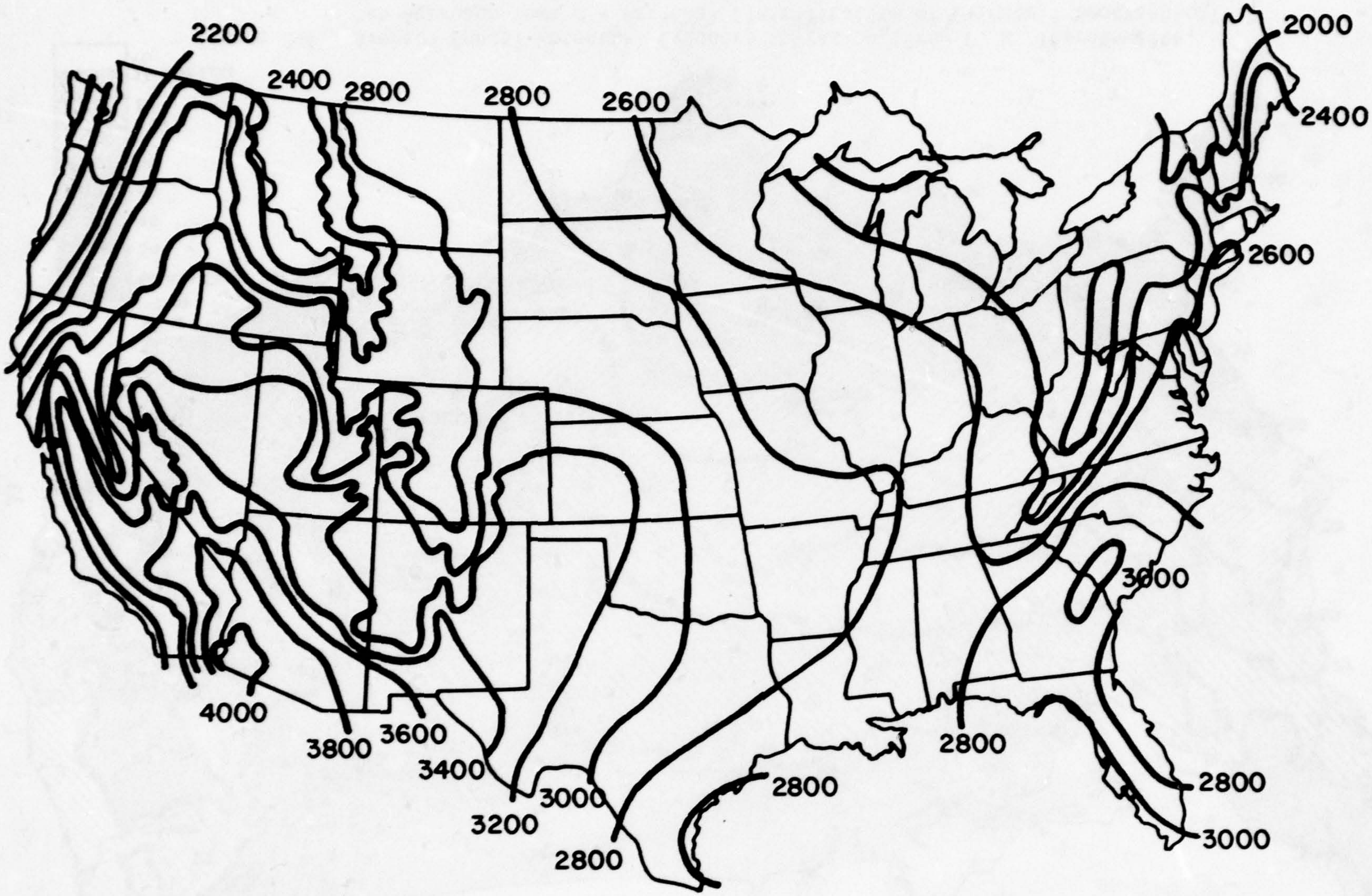

Figure C-5. Mean Annual Sunshine (Hours)(From U.S. Department of Interior, Geological Survey, National Atlas of United States of America)

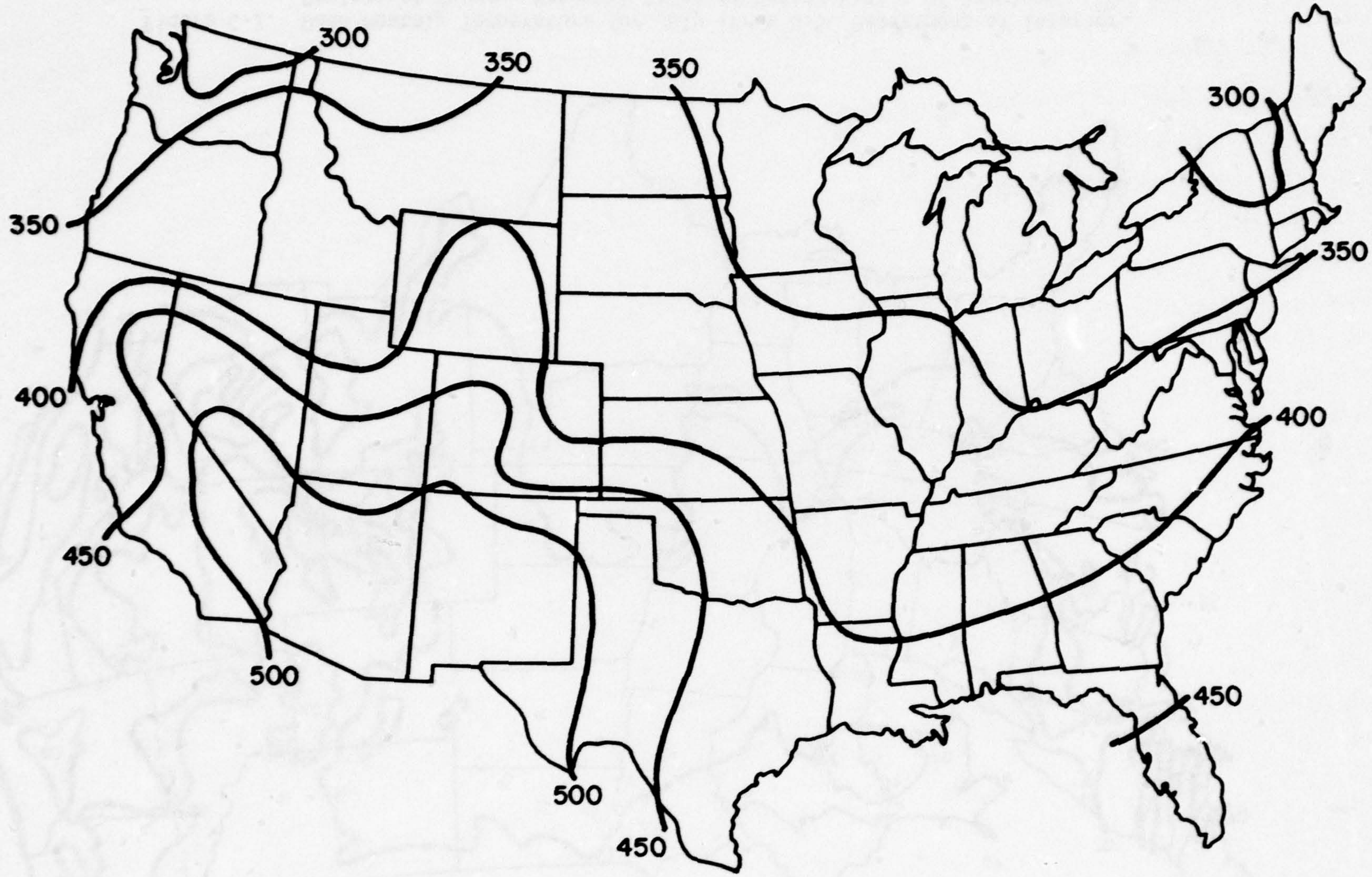

Figure C-6. Average Daily Solar Radiation (Langleys/day) (From U.S. Department of Interior, Geological Survey, National Atlas of United States of America)

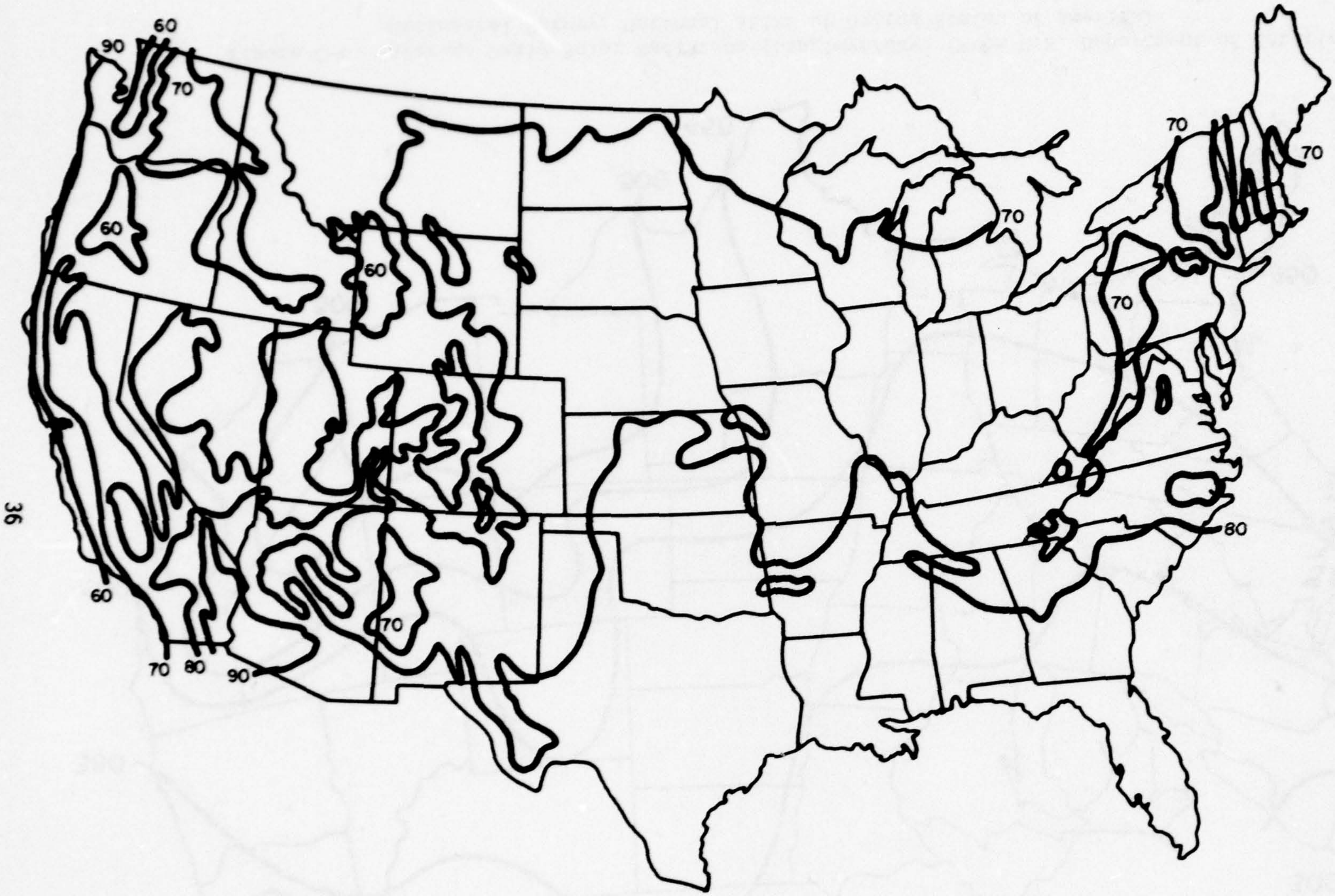

Figure C-7. Mean Monthly Temperature for July (From U.S. Department of Interior, Geological Survey, National Atlas of United States of America)

Comparing precipitation with the potential evapotranspiration provides a means of determining the moisture available for runoff and addition to the soil moisture. This comparison is termed the Thornthwaite Moisture Index, and it indicates whether there is a yearly surplus or deficit of moisture available to add to the soil. Moisture is added to the soil in any month when the precipitation exceeds the potential evapotranspiration, and moisture is removed from the soil during any month when the potential evapotranspiration exceeds the precipitation. Because a given soil can store a given quantity of moisture before runoff occurs, a value for this storage must be assumed. Thornthwaite assumed an average value of 4 inches of water in the storage capacity that can exist to combat drought in a dry year.[2] When moisture addition exceeds this value, a surplus occurs; when moisture loss reduces storage below zero, a deficit occurs. The Thornthwaite Moisture Index for the United States is shown in Figure C-8, which indicates that the West and the Southwest are drier than the East and Northwest. The Thornthwaite Moisture Index provides a numerical indicator of the availability of moisture in a given area. The United States can be divided into several general moisture regions based on this indicator.

Figure C-9 illustrates the monthly variation of the data used to calculate the Thornthwaite Moisture Index for Dalhart, Texas. The figure shows that there are several distinct periods of the year which affect where the soil stores moisture or loses moisture. In Dalhart, Texas, the soil never reaches its storage capacity and produces runoff. This soil could be considered dry for the entire year since it is continually absorbing moisture.

Data compiled by Thornthwaite for numerous cities[3]--Grand Junction, Colorado, Santa Fe, New Mexico, and Helena, Montana--show soil moisture characteristics similar to those of Dalhart, Texas, i.e., they do not experience runoff. Similarly, the cities that never experience a deficit are: Brevard, North Carolina; Salisbury, New York; Bar Harbor, Maine; Willard, North Carolina; and Madison, Wisconsin.

Between these two extremes are the area that experience runoff during part of the year, and a deficit during the other part of the year. Cities in this category include North Head, Washington; Louisville, Kentucky; Seattle, Washington; Canton, Mississippi; Manhattan, Kansas; Centennial, Wyoming; Pullman, Washington; San Francisco, California; and Los Angeles, California. The major variable between each of these cities is the total amount of the runoff that occurs and the amount of the deficit. Three moisture zones were differentiated in order to indicate the potential for moisture influence on the pavement: (1) wet all year, (2) seasonally dry, and (3) dry all year.

Zone 1 contains all areas that show a moisture surplus the entire year or have only a very minor deficit--usually less than one-half the

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[2] C. W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," Geographical Review, Volume 38, pp. 55-97, 1948.
[3] Ibid.

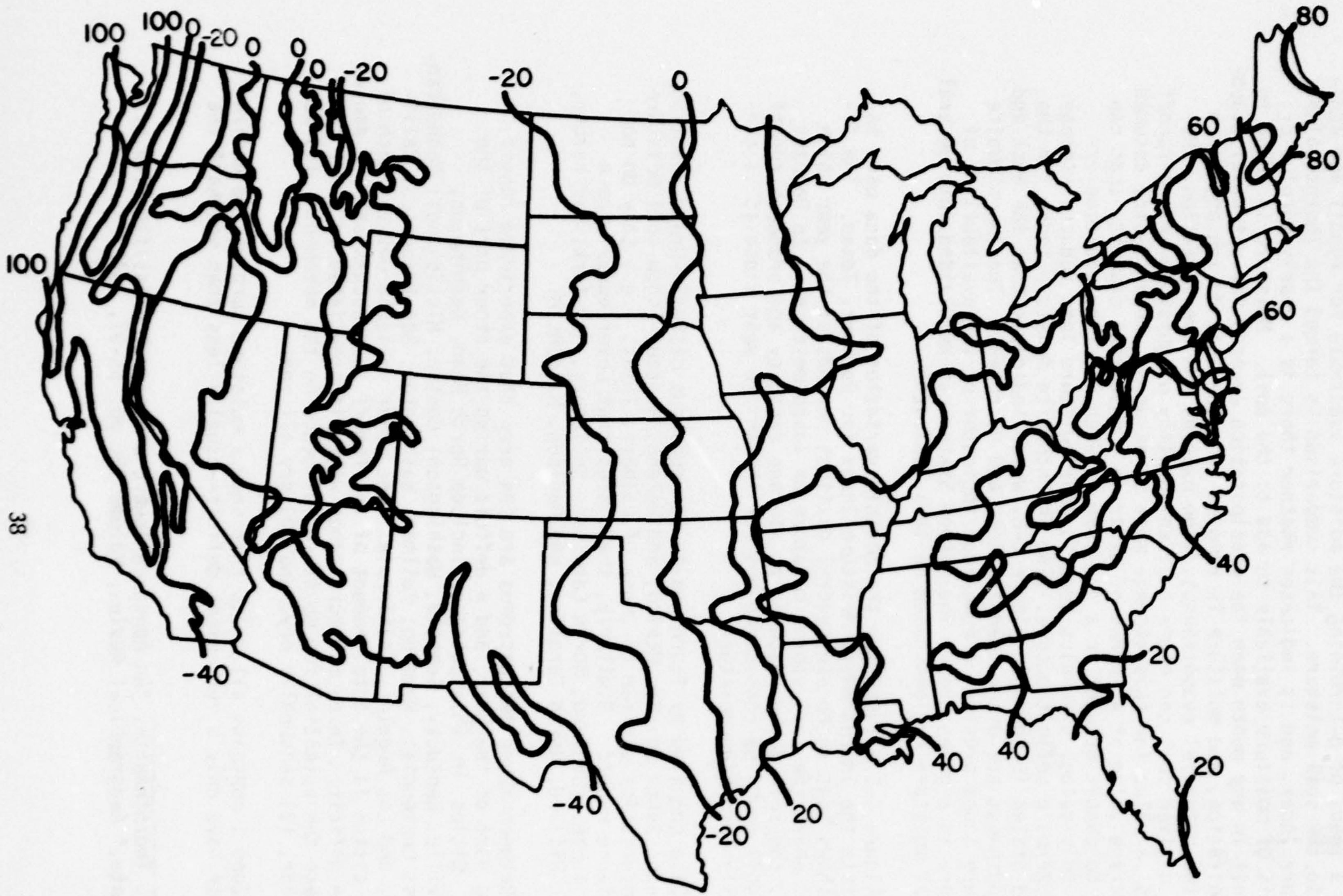

Figure C-8. Thornthwaite Moisture Index (From C. W. Thornthwaite, "An Approach Toward a Rational Classification of Climate," Geographical Review, Volume 38, pp. 55-97, 1948)

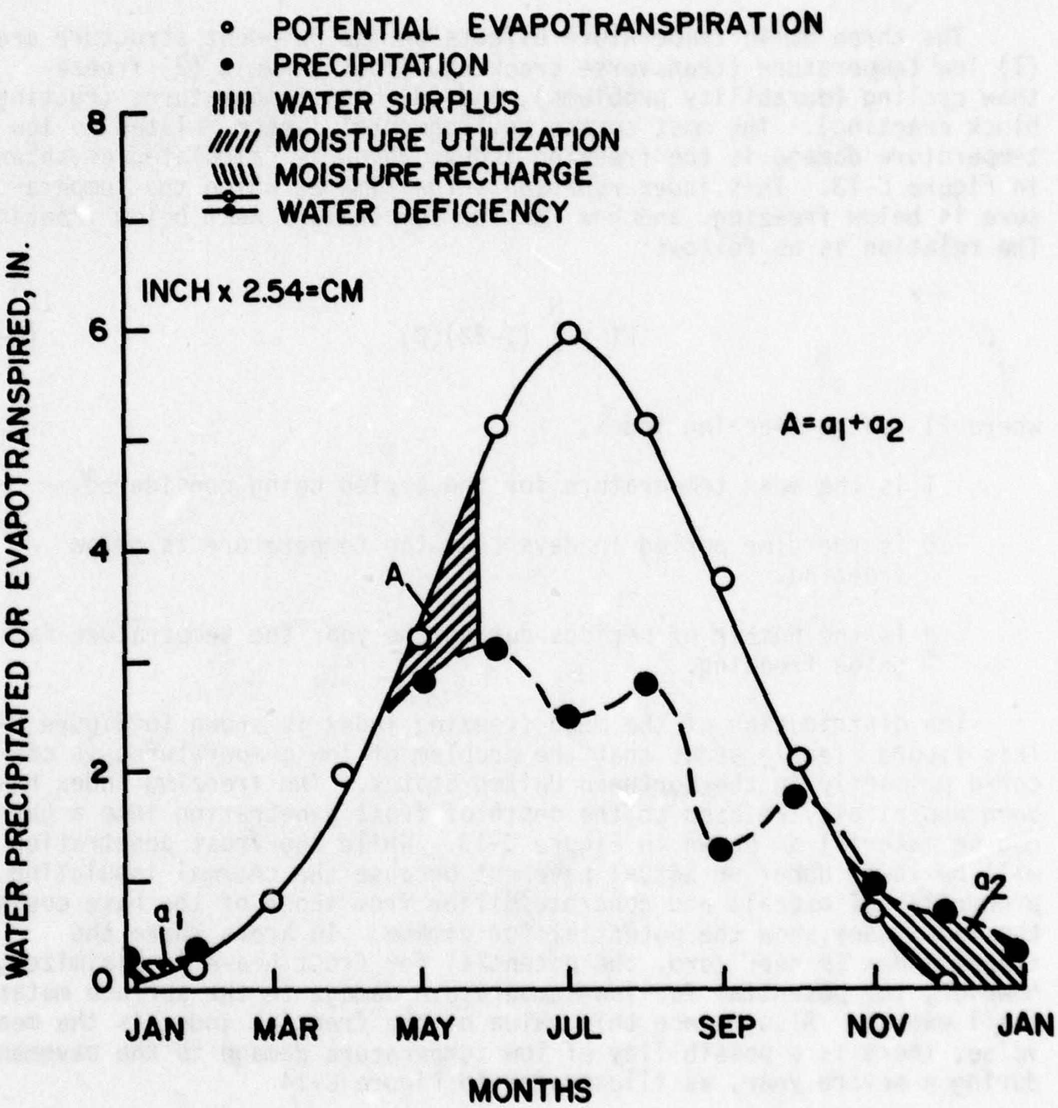

Figure C-9. Profile of Annual Precipitation and Potential Evapotranspiration for Dalhart, Texas (From S. H. Carpenter, R. L. Lytton, and J. A. Epps, Environmental Factors Relevant to Pavement Cracking in West Texas, Technical Report 18-1 [Texas Transportation Institute, January, 1974])

summer runoff. This distinction allows for a larger storage value than the 4 inches, which is quite common for most soils. Zone 2 contains areas that show a surplus that is somewhat smaller than the deficit. Zone 3 contains the areas that show no surplus of moisture during the year and do not even begin to use the full extent of the soil moisture storage capacity. The three zones are shown in Figure C-10.

The three basic temperature effects on the pavement structure are: (1) low temperature (transverse cracking, frost heave), (2) freeze-thaw cycling (durability problems), and (3) high temperatures (rutting, block cracking). The most common environmental factor related to low temperature damage is the freezing index, which is calculated as shown in Figure C-13. This index represents the time at which the temperature is below freezing, and how far the temperature went below freezing. The relation is as follows:

$$FI = \sum^{N} (T-32)(D) \qquad \text{(C-1)}$$

where FI is the freezing index,

T is the mean temperature for the period being considered,

D is the time period in days that the temperature is below freezing,

N is the number of periods during the year the temperature falls below freezing.

The distribution of the mean freezing index is shown in Figure C-11. This figure clearly shows that the problem of low temperatures is centered primarily in the Northern United States. The freezing index has been empirically related to the depth of frost penetration into a base course material as shown in Figure C-13. While the frost penetration will be lower under an actual pavement because the thermal insulating properties of asphalt and concrete differ from those of the base course,[4] the index does show the potential for damage. In areas where the freeze index is near zero, the potential for frost heave is minimized; however, the potential for low-temperature damage to the surface material still exists. Also, since this value of the freezing index is the mean value, there is a possibility of low temperature damage to the pavement during a severe year, as illustrated in Figure C-14

[4]B. J. Dempsey, A Heat-Transfer Model for Evaluating Frost Action and Temperature-Related Effects in Multilayered Pavement Systems (Ph.D. Dissertation, University of Illinois, Department of Civil Engineering, 1969).

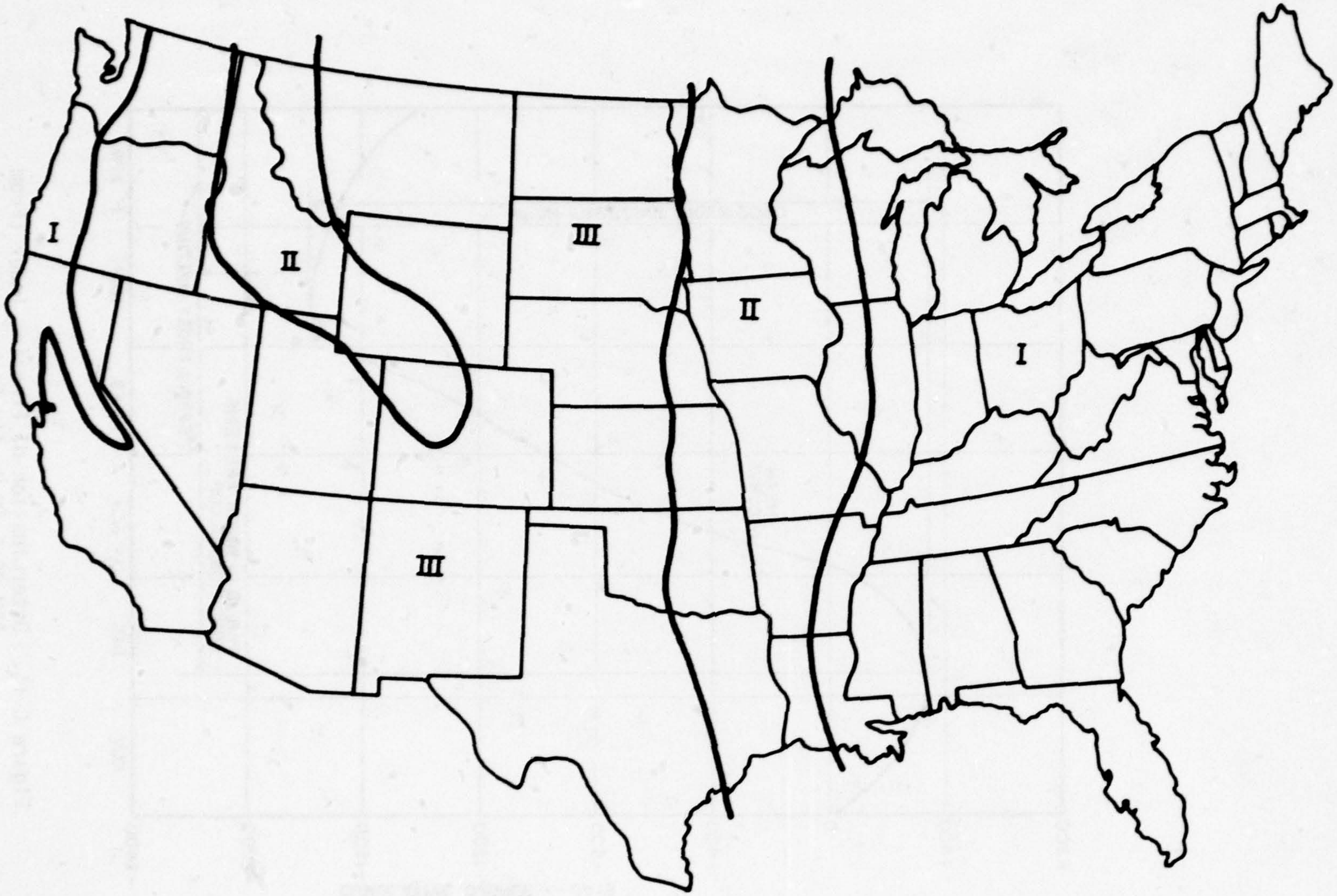

Figure C-10. Distribution of Moisture Zones

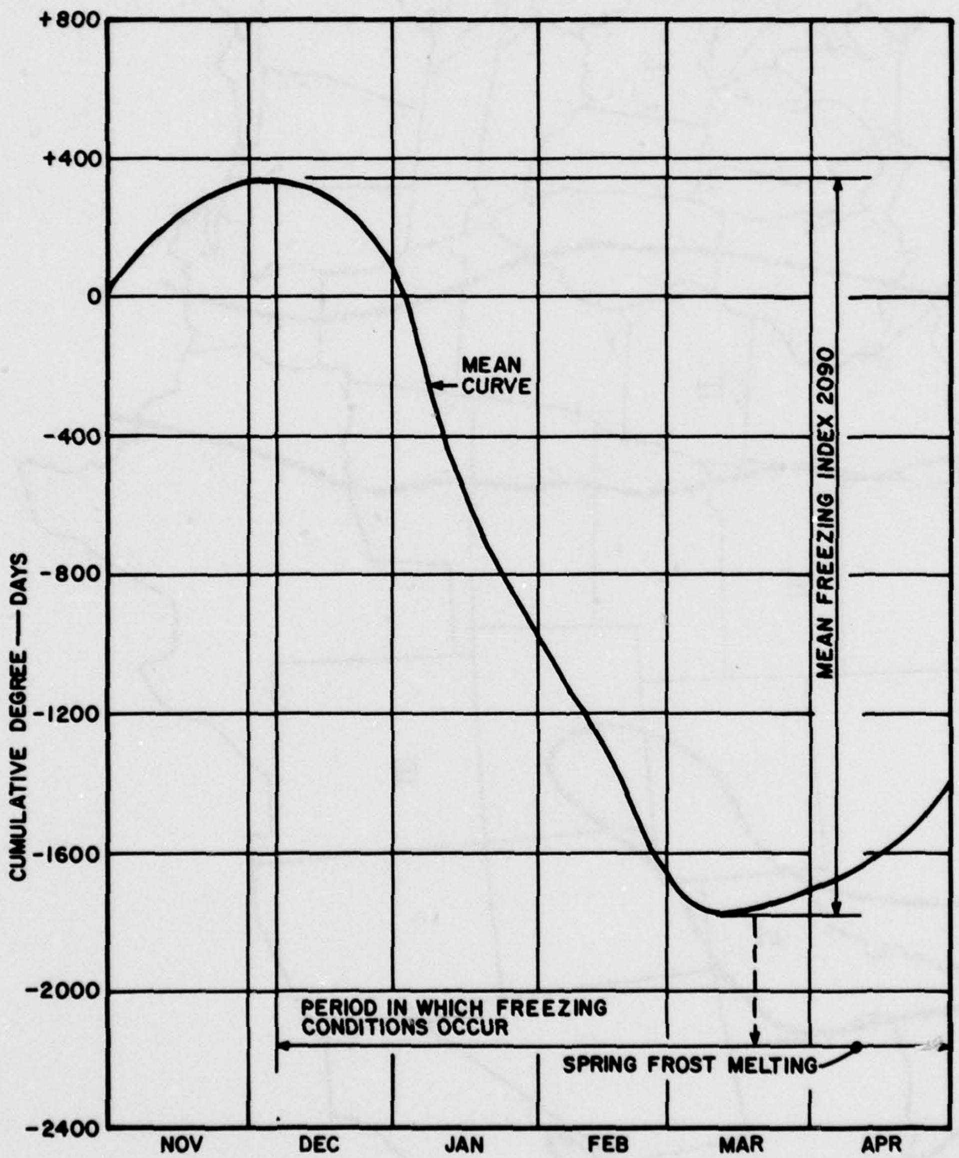

Figure C-11. Determination of Freezing Index (From AFM 88-6 [U.S. Air Force], Chapter 4)

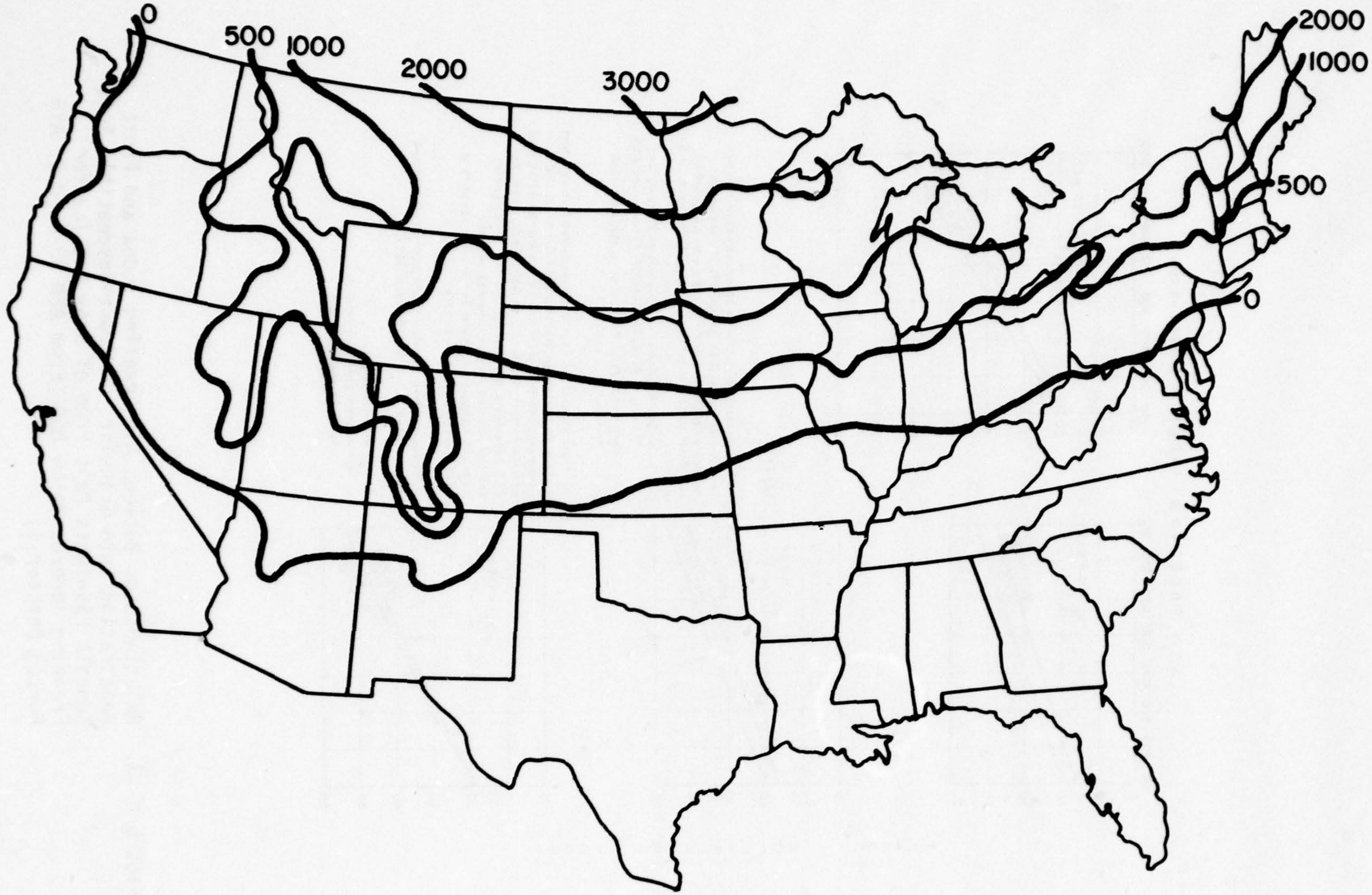

Figure C-12. Distribution of the Mean Freezing Index (From AFM 88-6, Chapter 4)

43

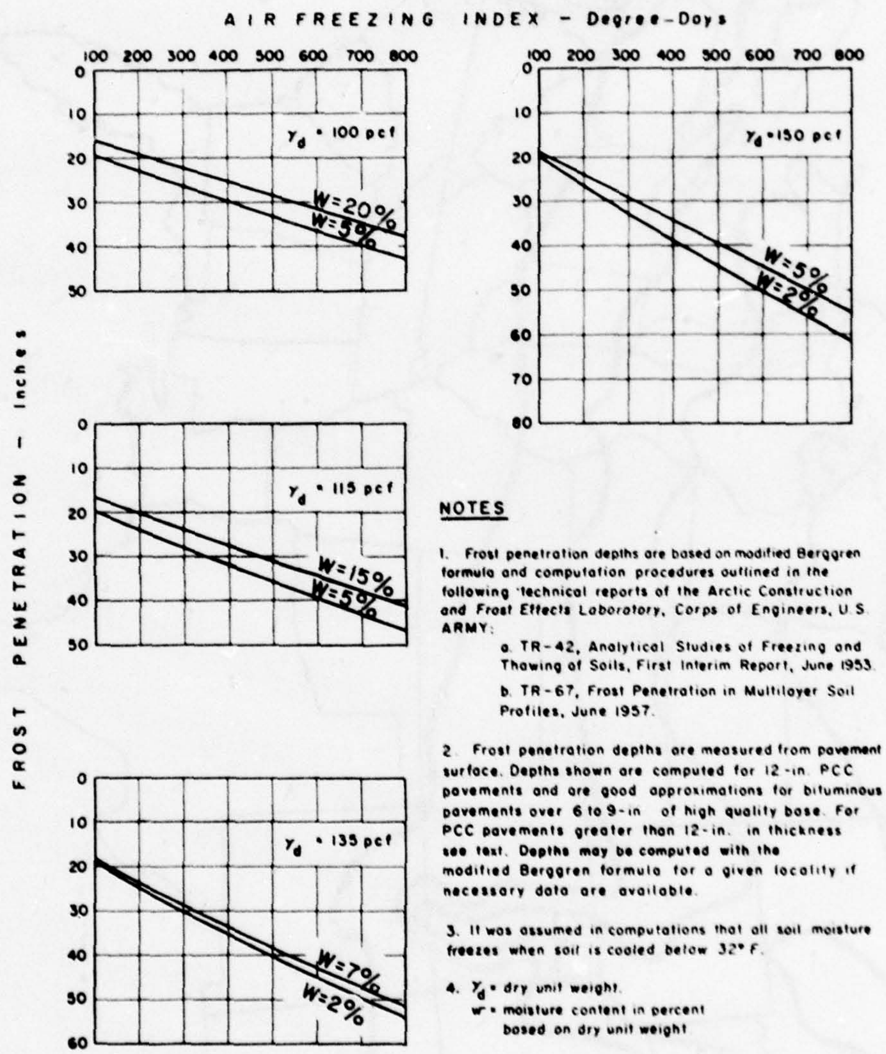

Figure C-13. Relationships Between Air Freezing Index and Frost Penetration Into Granular, Nonfrost-Susceptible Soil Beneath Pavements Kept Free of Snow and Ice for Freezing Indexes Below 800 (From AFM 88-6 [U.S. Air Force], Chapter 4)

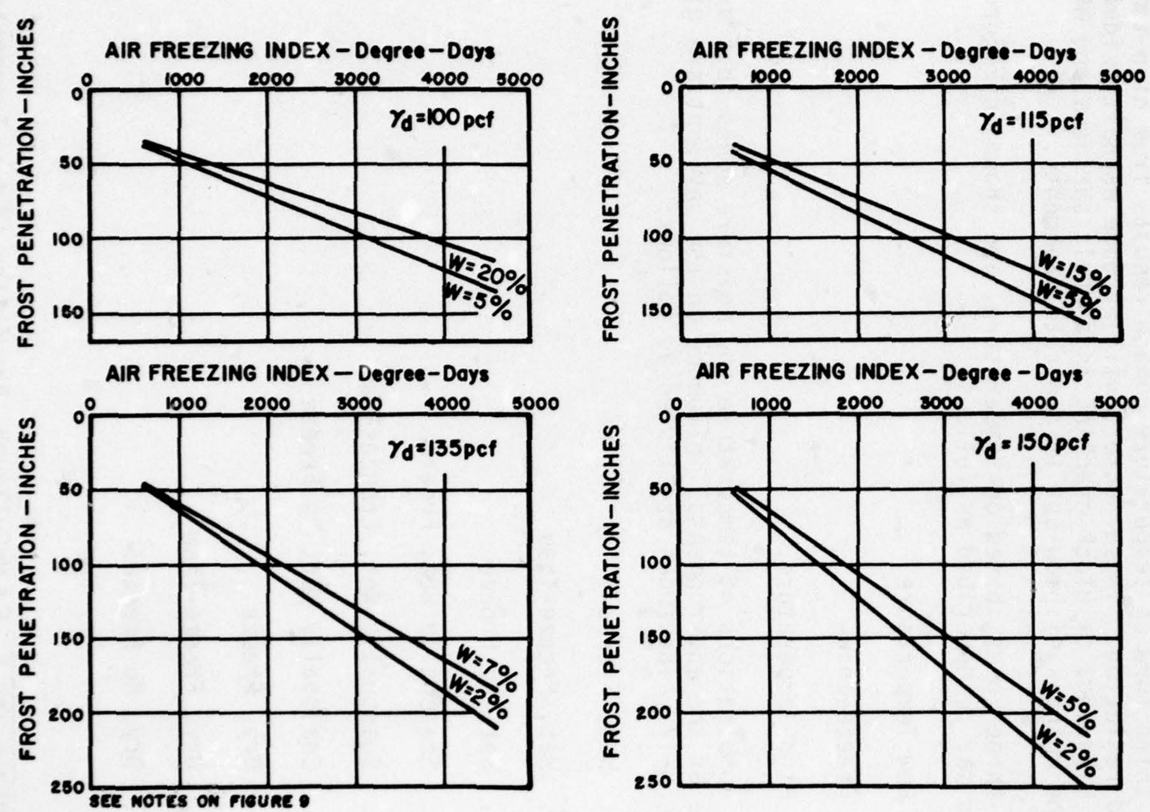

Figure C-14. Relationships Between Air Freezing Index and Frost Penetration Into Granular, Nonfrost-Susceptible Soil Beneath Pavements Kept Free of Snow and Ice (From AFM 88-6 [U.S. Air Force], Chapter 4)

The second form of temperature damage involves freeze-thaw damage to the surface, and possibly the base course,[5,6] through thermal fatigue. As the mean freezing index approaches zero, the potential for freeze-thaw cycles extending into the base course may reach 16 for Abilene, Texas,[7] which is substantially below the area where the freeze index causes frost problems.

The third form of temperature damage results from high temperatures and radiation. These factors will produce asphalt oxidation, rutting, bleeding, or block cracking in asphalt surfaces and will increase the chances of blow-ups in concrete pavements.

The three zones, based on temperature, are shown in Figure C-16. The zones may be described as follows:

A. Low Temperature

B. Freeze-Thaw

C. High Temperature.

The combinations of temperature and moisture zones that are representative of the environmental influence on the pavement are given again in Figure C-17. The zones are listed as follows:

I-A. Wet, Freeze

I-B. Wet, Freeze-Thaw

I-C. Wet, No Freeze

II-A. Seasonally Wet, Freeze

II-B. Seasonally Wet, Freeze-Thaw

II-C. Seasonally Wet, No Freeze

III-A. Dry, Freeze

III-B. Dry, Freeze-Thaw

III-C. Dry, No Freeze.

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[5]M. S. Shahin and B. F. McCullough, Prediction of Low Temperature and Thermal Fatigue Cracking in Flexible Pavements (Research Report 123-14, Center for Highway Research, 1972).
[6]S. H. Carpenter, R. L. Lytton, and J. A. Epps, Pavement Cracking in West Texas due to Freeze-Thaw Cycling, Transportation Research Board Record 1-13 (1975) 532 pp.
[7]Ibid.

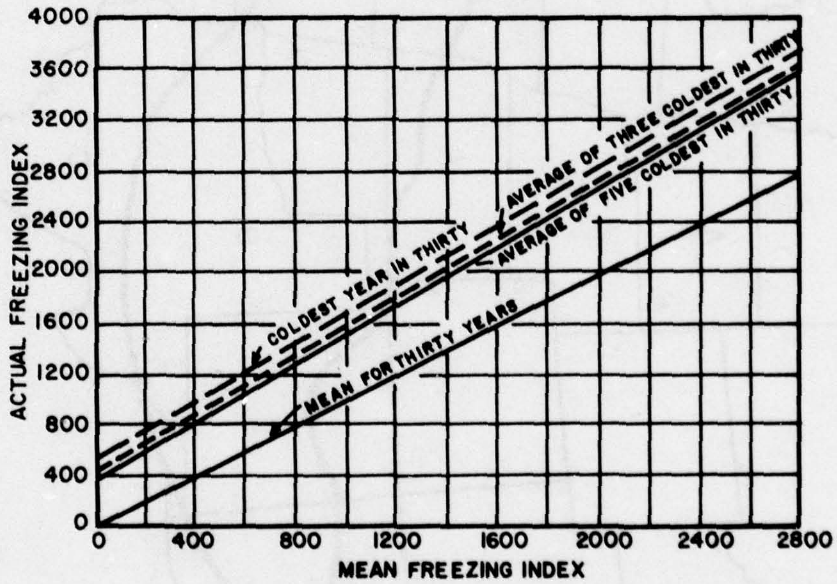


Figure C-15. Relationships of Freezing Index (From AFM 88-6, Chapter 4)

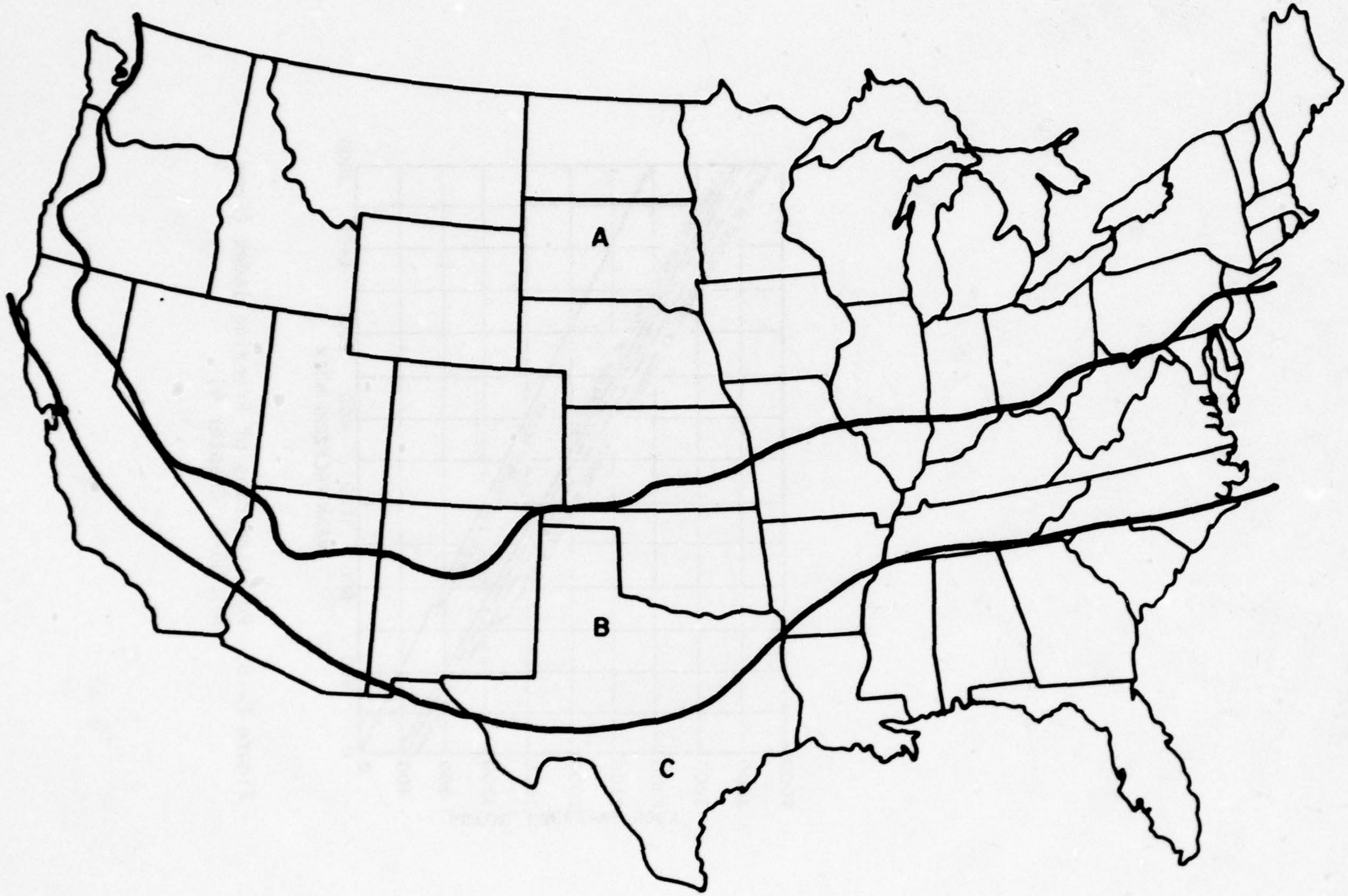


Figure C-16. Zones of Temperature Influence

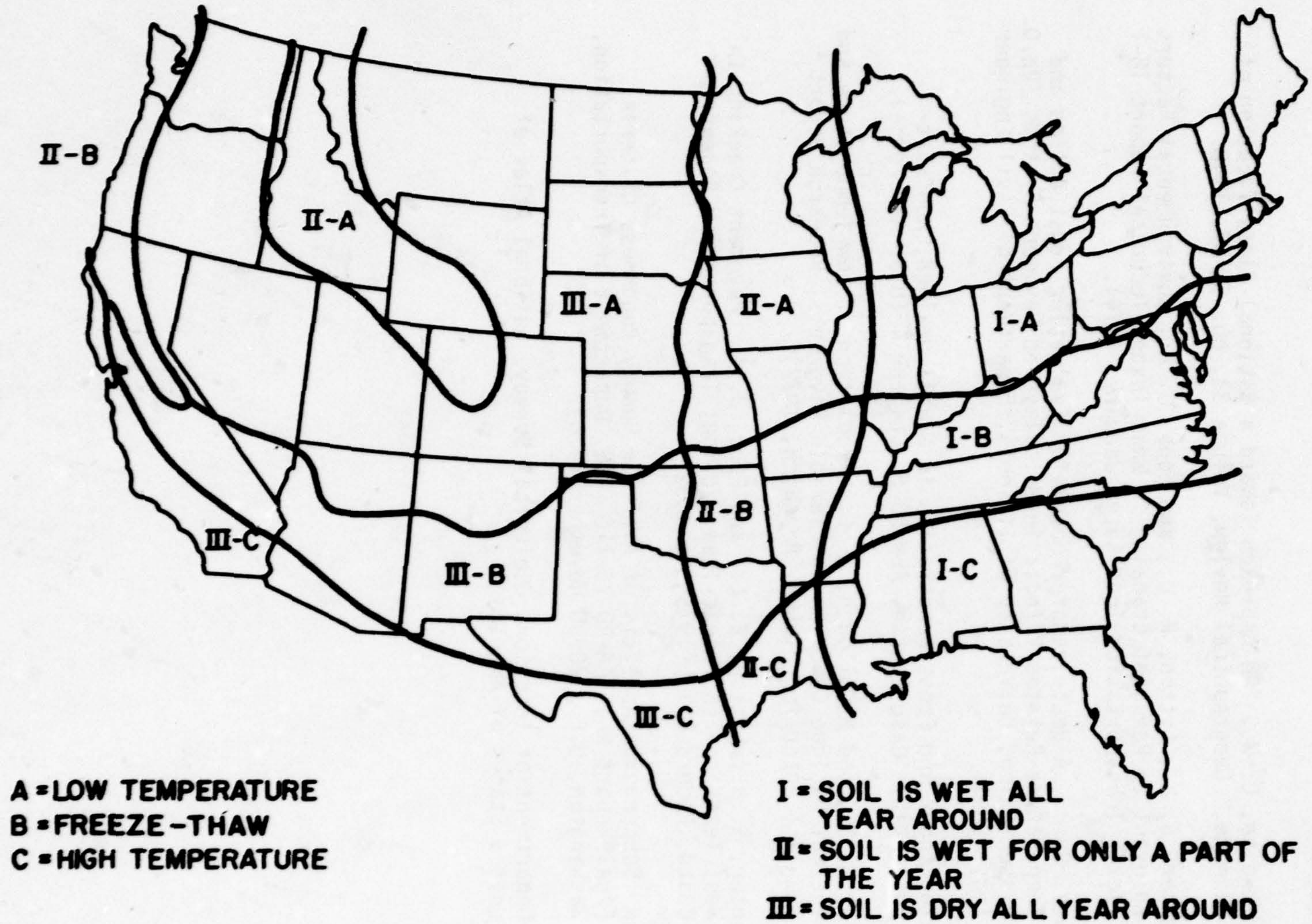


Figure C-17. Environmental Zones

REFERENCES

Thornthwaite, C. W., "An Approach Toward a Rational Classification of Climate," Geographical Review, Volume 38, pp. 55-97, 1948.

Carpenter, S. H., Lytton, R. L., and Epps, J. A., Environmental Factors Relevant to Pavement Cracking in West Texas, Technical Report 18-1 (Texas Transportation Institute, January, 1974).

Dempsey, B. J., A Heat-Transfer Model for Evaluating Frost Action and Temperature-Related Effects in Multilayered Pavement Systems (Ph.D. Dissertation, University of Illinois, Department of Civil Engineering, 1969).

Freezing Index and Frost Penetration in a Well-Drained, Nonfrost-Susceptible Base Course, AFM 88-6, Chapter 4 (U.S. Air Force).

Shahin, M. S., and McCullough, B. F., Prediction of Low Temperature and Thermal Fatigue Cracking in Flexible Pavements, Research Report 123-14 (Center for Highway Research, 1972).

Carpenter, S. H., Lytton, R. L., and Epps, J. A. Pavement Cracking in West Texas due to Freeze-Thaw Cycling, Transportation Research Board, Record 1-13 (1975), p. 532.

Paul N. Sonnenburg, Analysis of Airfield Runway Roughness Criteria, Final Report No. FAA-RD-75-110 (U.S. Department of Transportation, Washington, D.C., 20590 November 1976).

U.S. Department of Interior, Geological Survey, National Atlas of United States of America.

APPENDIX D

QUESTIONNAIRES USED IN FIELD VISITS

This appendix contains the questionnaires used in the field to obtain: (1) background information on particular pavement features (questionnaires 1 and 2 and latest Air Force evaluation reports), (2) maintenance recommendations for the feature (questionnaires 3 and 4), (3) individual responses on M&R alternatives for individual distress types (questionnaire 5), and (4) information on the rate of deterioration of individual distress types (questionnaire 6).

QUESTIONNAIRE 1

TRAFFIC RECORD
DATA SHEET

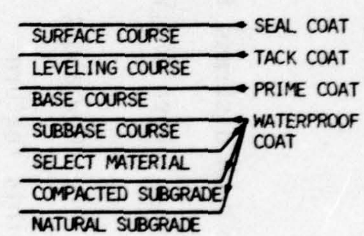
INSTALLATION NAME LOCATION	DATE	FEATURE NAME
	TRAFFIC AREA A B C D	
PAST TRAFFIC ESTIMATE		
AIRCRAFT TYPE	OPERATIONS/YEAR	
PRIMARY AC		
SECONDARY AC		
OTHER		
PRESENT TRAFFIC ESTIMATE		
PRIMARY AC		
SECONDARY AC		
OTHER		
FUTURE TRAFFIC ESTIMATE		
PRIMARY		
SECONDARY		
OTHER		
COMMENTS		

QUESTIONNAIRE 2

INSTALLATION			DATE			FEATURE		
CODE NO.	NAME	LOCATION	MO.	DAY	YR.	CODE NO.	SECTION	FACILITY NAME OR REF NO
							OF	

		MATERIAL	MATE-RIAL CODE	THICK-NESS IN.	DATE LAID	LOCATION (IF LESS THAN ENTIRE SECTION) FROM	TO
SURFACE TREATMENTS	SURF. TREAT (3)						
	SURF. TREAT (2)						
	SURF. TREAT (1)						
	FOG SEAL						
OVERLAYS	OVERLAY (3)						
	OVERLAY (2)						
	OVERLAY (1)						

		MATERIAL	MATE-RIAL CODE	THICK-NESS IN.	DATE LAID	COATINGS
INITIAL CONSTRUCTION	SURFACE					SEAL YES NO
	LEVELING					TACK YES NO
	BASE					PRIME YES NO
	SUBBASE					WATERPROOF YES NO
	SELECT					WATERPROOF YES NO
	COMPACTED SUBGRADE					WATERPROOF YES NO
	NATURAL SUBGRADE					



QUESTIONNAIRE 3

Field Distress Questionnaires

For each distress found: ____________________

1. When did you start observing this type of distress? __________

2. How about the rate of increase of quantity of this distress type in this feature

a. Slow initially then goes fast ____________________

b. At a constant rate ____________________

c. Does not hardly increase ____________________

3a. At what level of severity do you apply maintenance to this distress (in this feature)? ____________________

b. What maintenance method? ____________________

c. How about if you have large quantity of it (define large quantity ______________)? ____________________

M&R for Feature

Given current traffic and existing condition of the feature:

1. What maintenance activities would you perform on it this year?

2. What is your prediction of M&R a year from now? ____________

Two years from now? ________________________

Five years? ______________________________

Ten years? _______________________________

3. Below what level of PCI would you consider overlay or reconstruction?

4. Statement on past M&R on the feature ____________________.

5. Patching: How much patching is too much so that overlay or reconstruction should be considered?

Asphalt __________________________ ?

Concrete _________________________ ?

6. Slab Replacement: How much slab replacement is excessive so that overlay or reconstruction should be considered?

QUESTIONNAIRE 4

FEATURE M&R EVALUATION

FEATURE ____________________ AIRFIELD ____________________

NAME ____________________ DATE ____________________

1. Considering this feature as a primary pavement, which type(s) of maintenance and repair activities would you apply to the pavement within the next <u>two</u> years:

a. Nothing
b. Crack Sealing
c. Joint Sealing
d. Fog Seal
e. Slurry Seal
f. Shallow Patch
g. Deep Patch
h. Slab Replacement
i. Heater Planing
j. Overlay
k. Remove and Reconstruct
l. Other ____________________

2. Within 3 to 5 years:

a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.

3. Within 6 to 10 years:

a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.

FACTORS THAT MADE YOU DECIDE ON A MAJOR REPAIR?

FOR MAJOR REPAIR, HOW DO YOU SELECT THE ALTERNATIVE?

FACTORS?

DO YOU PERFORM ECONOMIC ANALYSIS?

QUESTIONNAIRE 5

COMMENTS ON MAINTENANCE AND REPAIR METHODS AND DISTRESS TYPES

The two tables presented on the following pages list the M&R methods associated with the particular distress types in CERL Technical Report C-76, "Development of a Pavement Maintenance Management System," Volume I, Chapter 8. As you examine these tables, consider the following questions:

1. In your opinion, does the M&R method work well for the distress type it is listed for, and if you do not think it does, indicate that you have had negative experience with this particular combination.

2. Have you used other M&R methods not listed on this type of distress?

TABLE FOR MAINTENANCE AND REPAIR METHODS FOR CONCRETE PAVEMENTS

M&R METHOD	DISTRESS TYPE	COMMENTS
Deep Patch	Blow Up	
	Corner Break	
	Longitudinal, Transverse, and Diagonal Cracking	
	"D" Cracking	
	Spalling Along Joints	
Slab Replacement	Blow Up	
	"D" Cracking	
	Large Patching and Utility Cut	
	Scaling, Map Cracking, and Crazing	
	Shattered Slab	
Crack Filling	Corner Break	
	Longitudinal, Diagonal, and Transverse Cracking	
	Spalling Along Joints	
	Corner Spall	

TABLE FOR MAINTENANCE AND REPAIR METHODS FOR ASPHALT PAVEMENTS

M&R METHOD	DISTRESS TYPE	COMMENTS
Crack Filling	Block Cracking	
	Joint Reflection Cracking	
	Longitudinal and Transverse Cracking	
Slurry Seal	Block Cracking	
	Raveling and Weathering	
Fog Seal	Block Cracking	
	Raveling and Weathering	
Rejuvenator	Block Cracking	
	Jet Blast Erosion	
Surface Leveling	Corrugations	
	Depressions	
	Swell	
	Rutting	
	Patching and Utility Cut Patch	

TABLE FOR MAINTENANCE AND REPAIR METHODS FOR ASPHALT PAVEMENTS

M&R METHOD	DISTRESS TYPE	COMMENTS
Shallow Patch	Depression	
	Joint Reflection Cracking	
	Longitudinal and Transverse Cracking	
	Rutting	

TABLE FOR MAINTENANCE AND REPAIR METHODS FOR ASPHALT PAVEMENTS

M&R METHOD	DISTRESS TYPE	COMMENTS
Deep Patch	Alligator Cracking	
	Depression	
	Rutting	
	Slippage Crack	
Heater Planner or Blade	Bleeding	
	Corrugation	
	Shoving	
	Swell	
Reprocessing	Block Cracking	
	Corrugation	
	Swell	
	Rutting	
Apply and Roll Sand Coat	Bleeding	

TABLE FOR MAINTENANCE AND REPAIR METHODS FOR CONCRETE PAVEMENTS

M&R METHODS	DISTRESS TYPE	COMMENTS
Shallow Patch	"D" Cracking Spalling Along Joints Scaling, Map Cracking, and Crazing Corner Spall	
Patch Replacement	Shallow and Deep Patches	
Joint Sealing Undersealing	Pumping	
Slab Jacking, Grinding	Settlement, Faulting	

QUESTIONNAIRE 6

QUESTIONNAIRES ON RATE OF DISTRESS DETERIORATION

Rate of distress deterioration is extremely important in determining maintenance needs and establishing maintenance policies. The rate of deterioration, however, is to a large extent a function of climatic conditions and traffic. Therefore, the United States has been divided into nine environmental zones with different environmental effects on pavement performance (Figure D-1).

The attached questionnaires are for you to provide an estimate of the rate of distress deterioration in the environmental zones that you have bases in. Specifically, you are to indicate the approximate time range (in years) it takes each distress to progress from Low* to Medium Severity and from Medium to High Severity. The size of the time range should be kept under 2 or 3 years if possible.

An example** of filling in the questionnaires for alligator cracking is shown in Table D-1. Your assistance will be greatly appreciated.

* The definitions of low, medium, and high severity levels of each distress are provided in CEEDO-TR-77-44(AFCEC-TR-72-27), Volume II, "Airfield Pavement Distress Identification Manual."

**Similar questionnaires were provided for different distress types in asphalt- and cement-surfaced pavements.

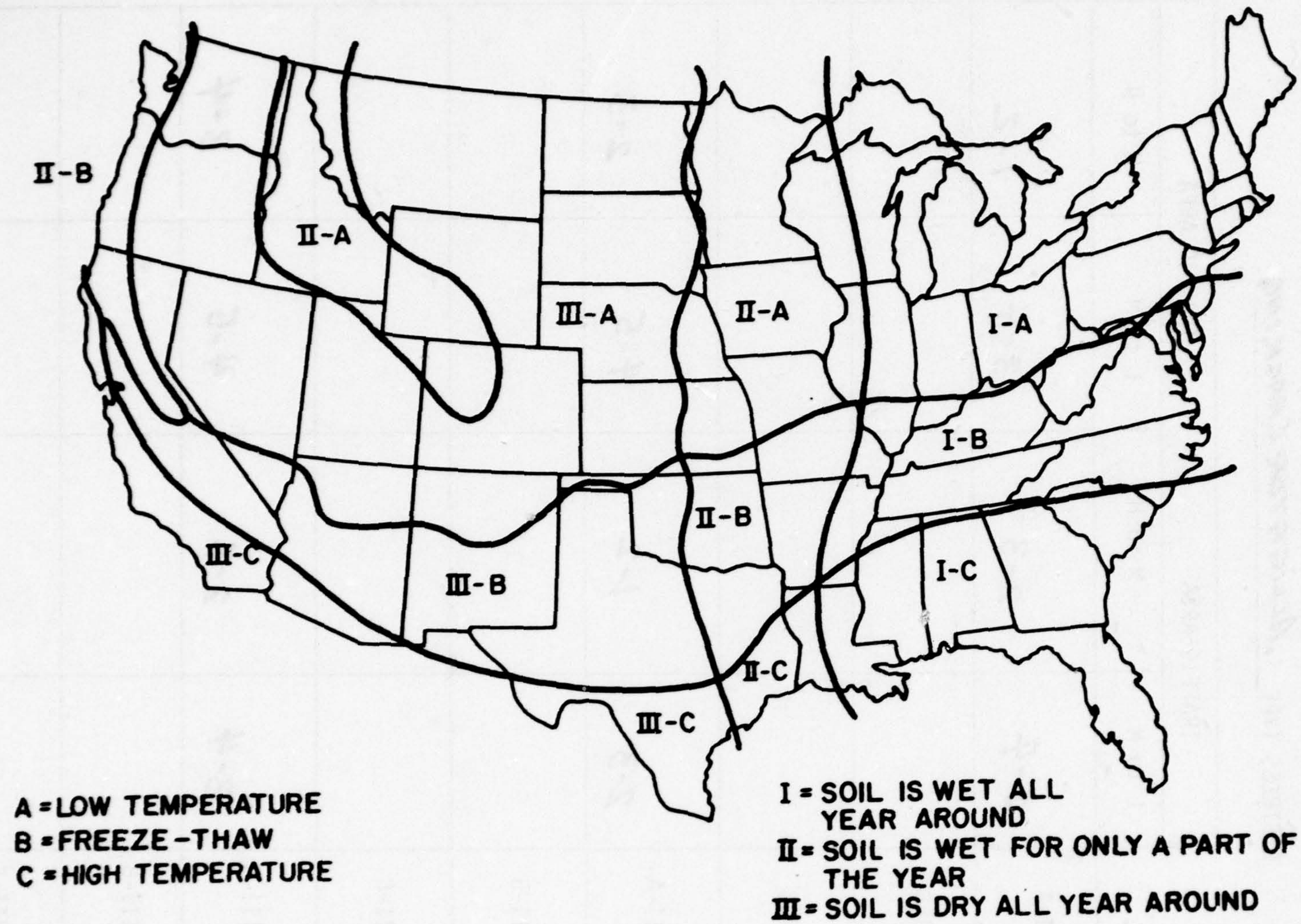


Figure D-1. Environmental Zones

TABLE D-1. EXAMPLE QUESTIONNAIRE

DISTRESS TYPE ALLIGATOR CRACKING

ENVIRONMENTAL ZONE	TRAFFIC AREA L to M	TRAFFIC AREA M to H	TRAFFIC AREA L to M	TRAFFIC AREA M to H
I-A	2-4	2-3	3-4	1-2
I-B				
I-C				
II-A	2-3	1-2	4-5	2-3
II-B				
II-C				
III-A	3-4	2-3	4-5	3-4
III-B				
III-C				

APPENDIX E

SUMMARY OF PCI DATA FOR FY77

The PCI data for each feature and sample unit surveyed in FY77 are summarized in Tables E-1 and E-2 for concrete and asphalt features, respectively. The data from all five bases are shown.

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 1	T1	1	25	
		2	27	
		3	47	
		4	32	
		5	22	
		6	38	
		7	28	
		8	33	
				32
	T2	1	30	
		2	61	
		3	21	
		4	28	
		5	36	
		6	16	
		7	35	
		8	39	
		9	33	
		10	22	
				32
	T3	1	62	
		2	80	
		3	71	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 1 Cont.	T3 Cont.	4	68	
		5	68	
		6	45	
		7	85	
				68
	R1	1	22	
		2	39	
		3	30	
		4	33	
		5	35	
		6	59	
		7	79	
				42
BASE 2	R1	1	64	
		2	40	
		3	45	
		4	59	
		5	66	
		6	53	
		7	48	
				54

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R2	1	41	
BASE		2	47	
2		3	48	
Cont.		4	60	
		5	70	
		6	68	
		7	62	
		8	63	
		9	69	
		10	50	
		11	70	
		12	43	
				58
	R3	1	69	
		2	54	
		3	37	
		4	41	
		5	41	
				48
	R4	1	79	
		2	79	
		3	79	
		4	76	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R4 Cont.	5	84	
BASE		6	64	
2				77
Cont.				
	R5	1	76	
BASE		2	66	
2		3	78	
Cont.		4	74	
		5	77	
		6	75	
		7	72	
		8	75	
				74
	R6	1	61	
		2	75	
		3	79	
		4	84	
				75
	R7	1	71	
		2	69	
		3	68	
		4	75	
				71

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R8	1	80	
BASE		2	70	
2		3	63	
Cont.		4	63	
		5	69	
		6	66	
		7	64	
		8	56	
		9	65	
		10	79	
		11	68	
		12	52	
		13	74	
		14	55	
		15	60	
		16	68	
		17	60	
		18	59	
		19	67	
		20	65	
		21	71	
		22	75	
		23	63	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 2 Cont.	R8 Cont.	24	75	
		25	77	
				67
BASE 3	R1	1	85	
		2	78	
		3	75	
		4	78	
				79
BASE 3 Cont.	R2	1	82	
		2	88	
		3	76	
		4	72	
				80
	R3	1	88	
		2	50	
				69
	R4	1	70	
		2	76	
				73
	R5	1	83	
		2	93	
		3	88	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 3 Cont.	R5 Cont.	4	78	
				85
	R6	1	80	
		2	92	
		3	90	
		4	78	
				85
BASE 4	T1	1	24	
		2	60	
		3	45	
		4	49	
				45
	T2	1	37	
		2	17	
		3	55	
				36
	T3	1	67	
		2	70	
		3	88	
		4	87	
		5	80	
		6	57	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T3 Cont.	7	98	
BASE		8	94	
4		9	65	
Cont.		10	91	
				80
	T4	1	43	
		2	72	
		3	76	
		4	78	
		5	75	
		6	50	
		7	92	
		8	39	
		9	69	
		10	13	
				61
	T5	1	81	
		2	28	
		3	53	
		4	58	
		5	61	
		6	59	
		7	56	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T5 Cont.	8	62	
BASE				57
4	R1	1	72	
Cont.		2	69	
		3	44	
		4	73	
		5	80	
		6	41	
		7	77	
		8	70	
		9	73	
		10	74	
		11	79	
		12	78	
		13	77	
				70
	A1	1	25	
		2	16	
		3	30	
		4	56	
		5	60	
		6	75	
		7	58	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	A1 Cont.	8	51	
BASE		9	55	
4		10	74	
Cont.		11	67	
		12	38	
		13	52	
		14	53	
		15	66	
		16	61	
		17	68	
		18	56	
		19	58	
				54
	A1	1	41	
BASE		2	67	
5		3	51	
		4	53	
		5	85	
		6	79	
		7	82	
		8	46	
		9	83	
		10	71	

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	A1 Cont.	11	58	
BASE		12	61	
5		13	68	
Cont.		14	64	
				65
	A2	1	68	
		2	86	
		3	87	
		4	55	
		5	71	
		6	72	
		7	73	
		8	65	
		9	88	
		10	89	
		11	74	
		12	44	
		13	89	
		14	64	
		15	94	
		16	77	
		17	91	
				76

TABLE E-1. SUMMARY OF P.C. CONCRETE FEATURES SURVEYED (CONCLUDED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 5 Cont.	A3	1	94	
		2	95	
		3	97	
		4	97	
		5	95	
		6	89	
				95

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R1	1	23	
BASE		2	16	
1		3	20	
		4	25	
		5	14	
		6	20	
		7	11	
		8	10	
		9	13	
		10	15	
		11	14	
		12	15	
		13	16	
		14	30	
		15	32	
		16	21	
		17	24	
		18	29	
		19	35	
		20	14	
				20
	R2	1	39	
		2	26	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R2 Cont.	3	39	
BASE		4	38	
1		5	44	
Cont.		6	55	
		7	46	
		8	49	
		9	33	
		10	47	
		11	39	
		12	38	
		13	53	
		14	42	
		15	46	
		16	42	
		17	44	
		18	48	
		19	40	
		20	65	
		21	55	
		22	52	
		23	49	
				43
	T1	1	33	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T1 Cont.	2	24	
BASE		3	12	
1		4	8	
Cont.		5	7	
		6	12	
		7	26	
				17
	R1	1	87	
BASE		2	89	
2		3	91	
		4	92	
		5	91	
		6	91	
		7	95	
		8	89	
		9	98	
		10	92	
		11	93	
		12	93	
		13	90	
				92
	R2	1	74	
		2	78	
		3	75	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R2 Cont.	4	81	
BASE		5	84	
2		6	75	
Cont.		7	81	
		8	80	
		9	68	
		10	72	
		11	65	
		12	76	
		13	67	
		14	65	
		15	63	
		16	66	
		17	69	
				73
	T1	1	84	
		2	85	
		3	64	
		4	86	
		5	83	
				80
	T2	1	88	
		2	76	
		3	45	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T2 Cont.	4	61	
BASE		5	29	
2		6	59	
Cont.		7	64	
		8	40	
				58
	T3	1	49	
		2	62	
		3	48	
		4	90	
		5	93	
		6	88	
		7	81	
		8	90	
		9	89	
		10	95	
		11	83	
		12	90	
		13	86	
				80
	T4	1	81	
		2	83	
		3	82	
		4	78	81

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 3	R1	1	57	
		2	70	
		3	75	
		4	73	
		5	64	
		6	58	
		7	79	
				68
	R2	1	70	
		2	74	
		3	73	
		4	86	
		5	81	
		6	74	
		7	84	
				77
	R3	1	83	
		2	88	
		3	83	
		4	84	
		5	87	
		6	83	
		7	87	
				85

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R4	1	90	
BASE		2	83	
3		3	86	
Cont.		4	71	
		5	81	
		6	89	
		7	85	
				84
	R5	1	86	
		2	91	
		3	88	
		4	92	
		5	89	
		6	92	
		7	93	
		8	85	
		9	95	
		10	98	
		11	81	
		12	92	
		13	84	
		14	86	
		15	81	
				89

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T1	1	38	
BASE		2	19	
3		3	47	
Cont.		4	28	
		5	33	
		6	20	
		7	22	
		8	16	
		9	16	
		10	19	
		11	53	
		12	18	
				27
	T2	1	22	
		2	5	
		3	0	
		4	21	
		5	11	
				12
	T3	1	71	
		2	62	
		3	62	
		4	49	
		5	57	

AD-A060 883 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAI--ETC F/G 13/2
DEVELOPMENT OF A PAVEMENT MAINTENANCE MANAGEMENT SYSTEM. VOLUME--ETC(U)
SEP 77 M Y SHAHIN, M I DARTER, S D KOHN

UNCLASSIFIED CERL-TR-C-76-VOL-4 CEEDO-TR-77-44-VOL-4 NL

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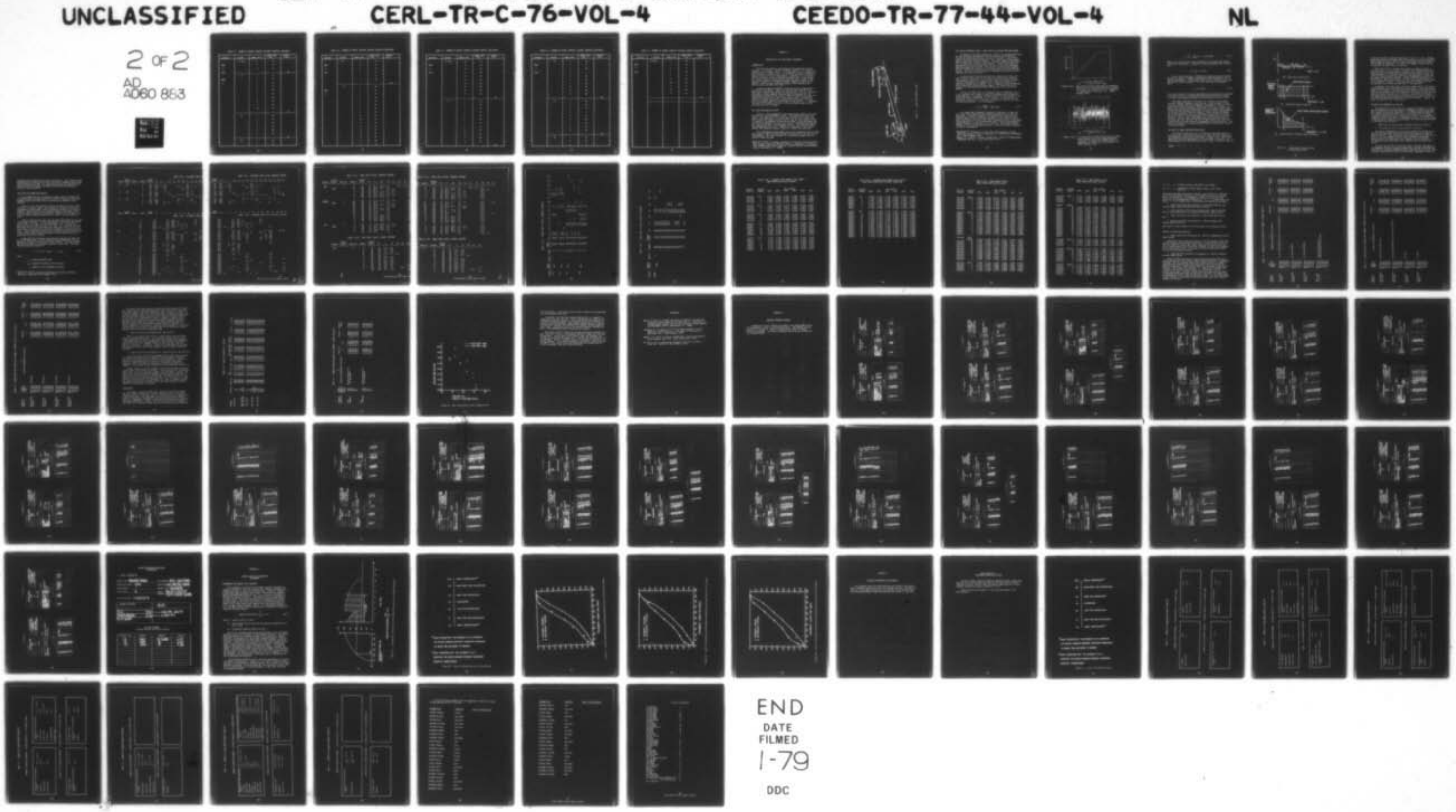

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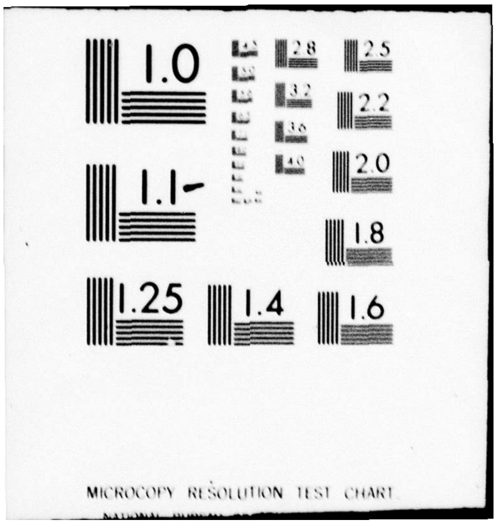
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MICROCOPY RESOLUTION TEST CHART

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
BASE 3 Cont.	T3 Cont.	6	73	
		7	74	
		8	73	
				65
BASE 4	R1	1	77	
		2	76	
		3	50	
		4	72	
		5	84	
		6	81	
		7	80	
		8	83	
		9	84	
		10	80	
				77
	R2	1	82	
		2	78	
		3	82	
		4	81	
		5	82	
		6	82	
				81
	R3	1	59	
		2	60	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R3	3	74	
BASE		4	76	
4		5	70	
Cont.		6	73	
		7	63	
		8	68	
				68
	R1	1	89	
BASE		2	87	
5		3	90	
		4	94	
		5	86	
		6	93	
		7	92	
		8	94	
		9	92	
		10	92	
		11	90	
		12	93	
		13	92	
		14	82	
		15	94	
		16	84	
		17	78	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	R1 Cont.	18	73	
BASE		19	83	
5		20	85	
Cont.		21	85	
		22	83	
		23	78	
		24	88	
		25	85	
		26	86	
		27	81	
				87
	T1	1	65	
		2	83	
		3	76	
		4	73	
		5	61	
		6	67	
		7	73	
		8	72	
		9	70	
		10	67	
		11	68	
		12	58	
				69

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONTINUED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T2	1	34	
BASE		2	51	
5		3	49	
Cont.		4	7	
		5	43	
		6	63	
		7	68	
		8	61	
		9	62	
		10	46	
				48
	T3	1	40	
		2	55	
		3	55	
		4	40	
		5	42	
		6	56	
		7	52	
		8	59	
		9	42	
				49
	T4	1	57	
		2	76	
		3	72	

TABLE E-2. SUMMARY OF ASPHALT CONCRETE FEATURES SURVEYED (CONCLUDED)

AIRFIELD	FEATURE	SAMPLE UNIT	SAMPLE UNIT PCI	FEATURE PCI
	T4 Cont.	4	53	
BASE		5	52	
5		6	72	
Cont.		7	66	
		8	73	
		9	68	
		10	49	
		11	57	
		12	60	
		13	57	
				63

APPENDIX F

CORRELATION OF PCI AND PROFILE ROUGHNESS

INTRODUCTION

The PCI rating reflects the structural and operational surface condition of a pavement. Vehicle vibration, however, is a function of pavement profile irregularities. It is possible to have a pavement in poor structural condition (with a low PCI) and yet have an effectively smooth contour for vehicle ride quality. Conversely, it is possible to have a pavement in good structural condition with a rough contour. This latter situation existed at Washington National Airport in 1972 when pilot complaints of roughness caused a complete resurfacing of asphalt. After the new surface was placed, pilot complaints were even stronger than before the repair.

A study was made to determine if PCI and profile roughness were correlated in any manner. Data from Ellsworth and Vance Air Force Bases were collected and analyzed for this purpose. The PCI ratings for the numerous runway segments were obtained in accordance with the methodology presented in this report. Profile elevation data were collected using the Air Force laser profilometer system. Conventional statistical methods were used to analyze the profile data to assess relative roughness and will be discussed in more detail in this appendix. The results of comparing PCI with a relative runway roughness index (the RMS level) will be shown.

THE LASER PROFILOMETER SYSTEM

Figure F-1 shows schematically the electrically powered carts that comprise the laser profilometer system. The forward cart, which contains a laser beam device, is driven some distance (for example, 300 feet to 600 feet) along a desired profile, and the laser support tripod is lowered to the pavement surface and the beam is directed towards the rear cart and leveled. The rear cart carries a tracking screen mounted on a wheel which rides on the pavement surface. The tracking screen is driven toward the laser cart. Elevation is computed in the tracking vehicle and recorded on magnetic tape for further data processing.

This profilometer system samples the profile elevation every 0.5 foot. The system is known to be more accurate (or consistent) than the rod and level method.[1] One line of survey of a 10,000-foot runway can be recorded in about one hour.

[1]Baum, N. P. and T. R. Stough, Evaluation of Intertial and Laser Profilometer Systems, Report No. FAA-RD-74-188 (U.S. Department of Transportation, Federal Aviation Administration, Systems Research and Development Service, Washington, D.C. 20590).

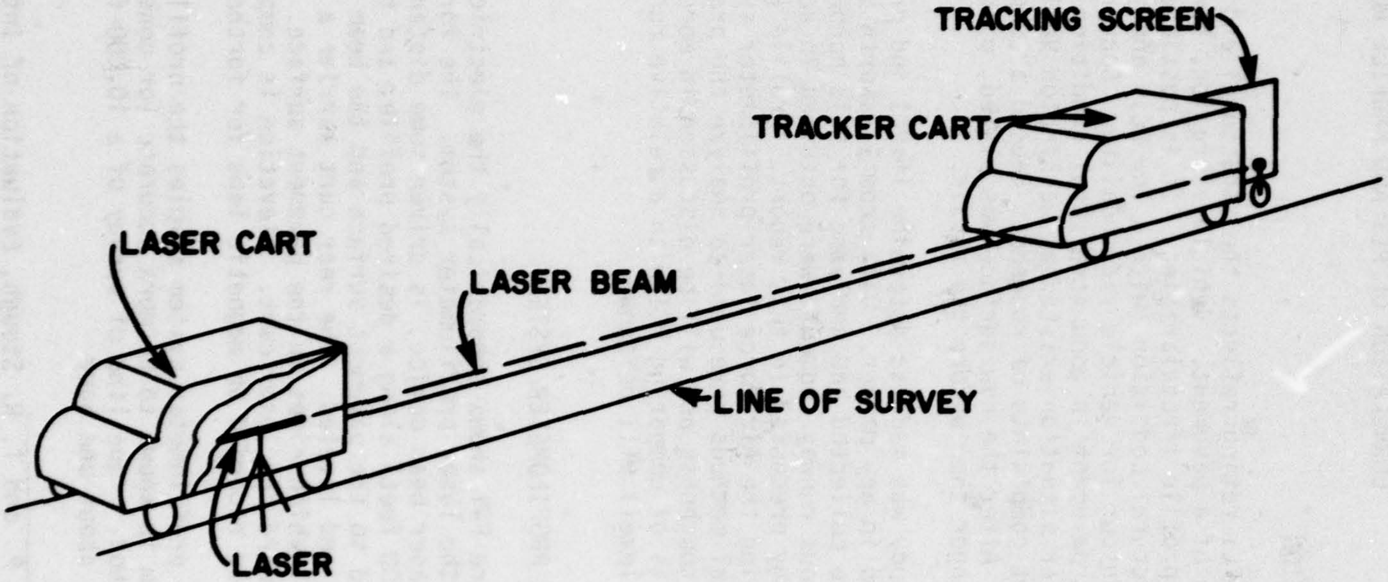


Figure F-1. Laser Profilometer System

THE SELECTED ROUGHNESS INDEX: BAND-LIMITED ELEVATION ROOT-MEAN-SQUARE

The measure of profile roughness was taken as the standard deviation (or the root-mean-square [RMS]) of profile elevation which has been filtered to remove overall grade or trend in the data. Figure F-2(A) shows a typical raw elevation profile. This trace contains wavelengths which do not affect aircraft vibration, and which render the data difficult or impossible to analyze statistically. Figure F-2(B) shows the appearance of the profile data after the long (> 400 foot) wavelengths have been removed by filtering. The vertical scale has been expanded, and the irregularities which affect aircraft vibration can be seen more clearly. All of the pertinent tools of mathematical statistics can be used with the data in this form.

It can be shown[2] that the variables of interest which affect aircraft vibration are elevation and slope (the derivation of elevation with respect to distance). For this work, only the variable of elevation was investigated. The parameter of interest was taken as the statistical second central moment. This is commonly called the variance and is equivalently called the mean square. The square root of this statistic is the standard deviation, RMS value as it will be called herein.

The use of an RMS value as a roughness index is meaningful only if it is associated with a band or range of wavelengths which causes aircraft vibration. For example, consider an aircraft which has one of its structural natural frequencies, f, at 1.0 hertz. If the aircraft is taxiing at a velocity, v, of 60 knots (100 feet per second), the critical profile wavelength, λ, is calculated as

$$\lambda = \frac{v}{f} = \frac{100.0}{1.0} = 100.0 \text{ feet} \qquad \text{(F-1)}$$

This means that a dangerous structural vibration or a rough ride will occur if the runway profile contains periodic waves of 100-foot wavelength. Aircraft, in general, are known to have significant and distinct modes of vibration between roughly 0.5 hertz and 15.0 hertz, while significant taxi velocities range from about 30 knots to 150 knots. Using Equation (F-1), the corresponding range of profile wavelengths of general interest is from about 3.3 to 500 feet. The highest (spatial) frequency in the digitized profile data is called the Nyquist frequency,[3] f_n, and is calculated as

[2]Sonnenburg, P. N., Analysis of Airfield Runway Roughness Criteria, Report No. FAA-RD-75-110 (U.S. Department of Transportation, Washington, D.C. 20590, November 1976).

[3]Bendat, J. S. and A. G. Piersol, Randon Data: Analysis and Measurement Procedures (New York: Wiley-Interscience, 1971).

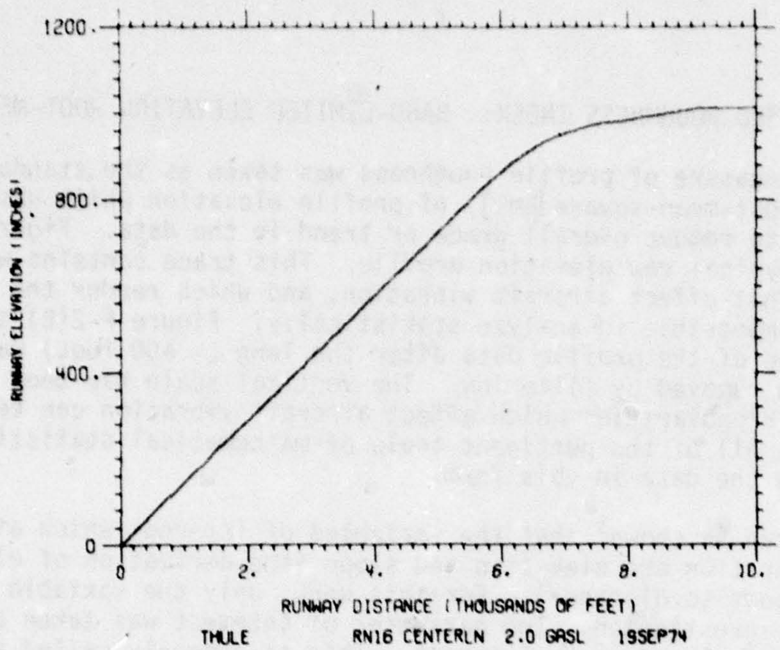


Figure F-2(A). Raw Elevation Profile (From Paul N. Sonnenburg, Analysis of Airfield Runway Roughness Criteria, Final Report No. FAA-RD-75-110, U.S. Department of Transportation, Washington, D.C. 20590, November 1976)

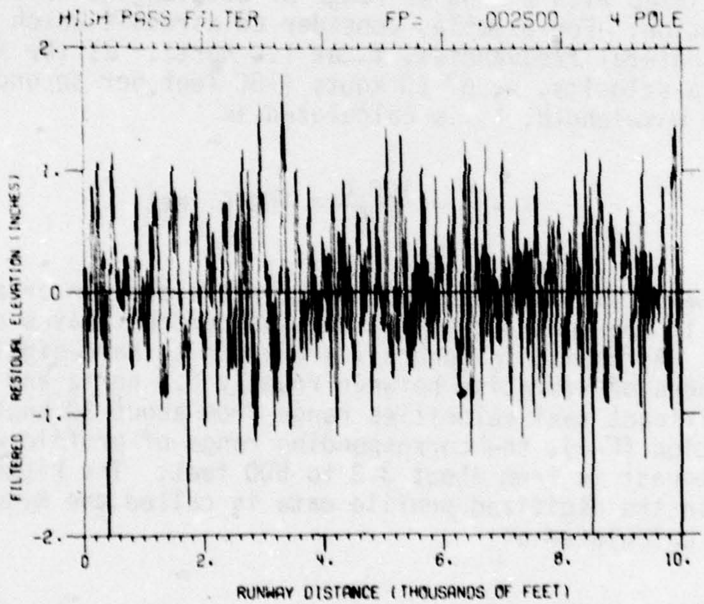


Figure F-2(B). Filtered Elevation Profile (From Paul N. Sonnenburg, Analysis of Airfield Runway Roughness Criteria, Final Report No. FAA-RD-75-110, U.S. Department of Transportation, Washington, D.C. 20590, November 1976)

$$f_n = \frac{1}{2\Delta} = \frac{1}{2(0.5)} = 1.0 \text{ cycle/foot} \qquad \text{(F-2)}$$

where Δ = 0.5 foot in the length of sampling of the laser profilometer. The shortest wavelength, λ_n, present in the raw elevation data is therefore

$$\lambda_n = \frac{1}{f_n} = 1.0 \text{ foot} \qquad \text{(F-3)}$$

At this digitizing rate, a 10,000-foot runway would require 20,000 data points, which is somewhat cumbersome and time-consuming to use in computer programming. If only every fourth point is selected, such that the sampling length increment is 2.0 feet, the Nyquist wavelength is then

$$\lambda_n = 4.0 \text{ feet} \qquad \text{(F-4)}$$

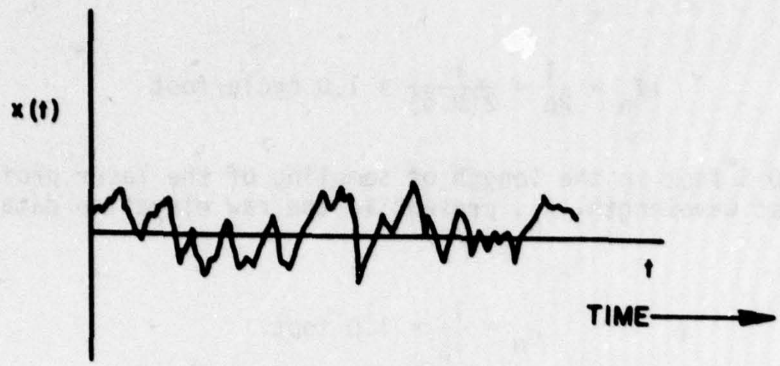
Thus, the selection of 2.0-foot increments places the shortest wavelength in the data closer to the approximate shortest wavelength of interest (3.3 feet), and reduces the number of data points by a factor of four.

The longest wavelength of interest is a function of the lowest structural natural frequency of an aircraft. Large transport carrier aircraft or bombers may have fundamental frequencies as low as 0.5 Hertz, while smaller aircraft may have frequencies as high as 2.0 Hertz. In general, the profile wavelengths which affect the lowest vehicle modes of vibration are the most significant, and cause the most severe portion of the total aircraft vibration response. Hence a particular runway may contain wavelengths which are detrimental to one type of aircraft but not to another. Long wavelengths of no interest can be removed by filtering. For this work, wavelengths above the respective value of 400 feet, 200 feet, 100 feet, 50 feet, 25 feet, and 10 feet have been filtered from the profile data for subsequent statistical analysis. The effect of filtering on the resulting RMS levels is significant, and will be discussed below.

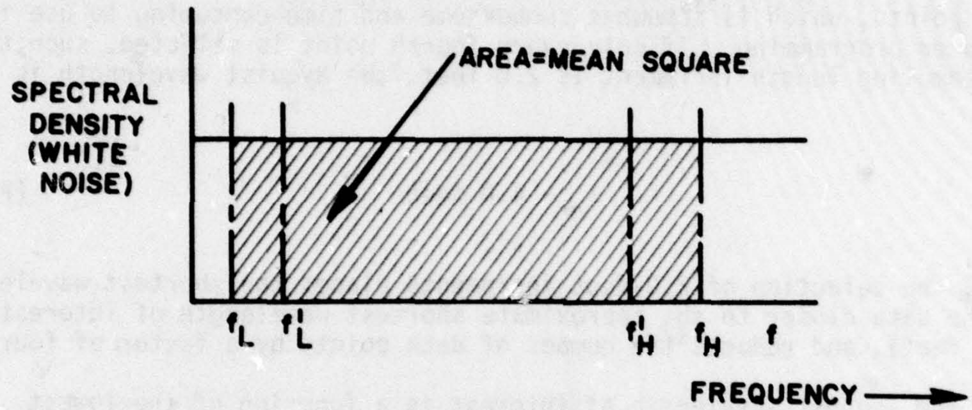
THE EFFECT OF BAND LIMITING ON RMS VALUES

The effect of band limiting, or filtering, on the RMS value of a profile can be illustrated in principle by referring to the analysis of the hypothetical white noise trace shown in Figure F-3(A). White noise means there are equal amplitudes of all wavelengths in the data. The spectral density[4] of the white noise trace is shown in Figure F-3(B), and

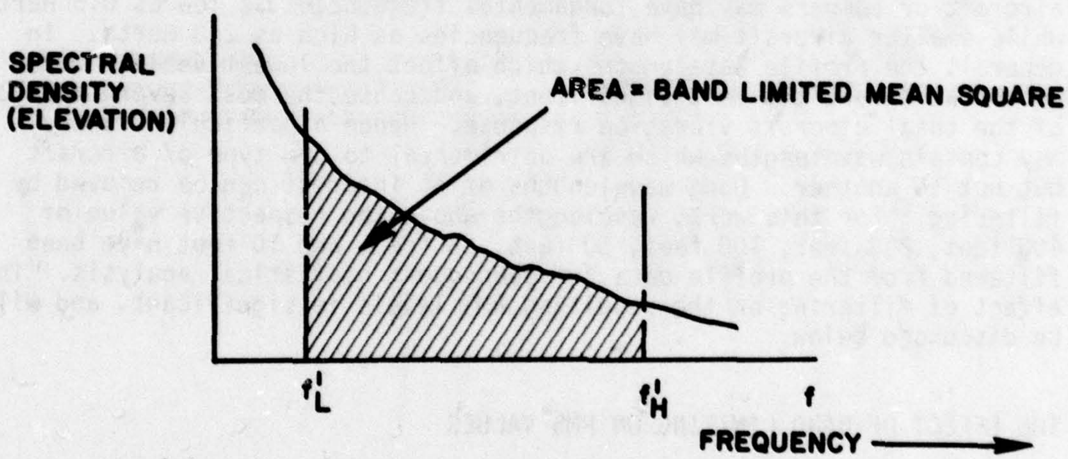
[4]Ibid.



(A). White Noise Time History



(B). White Noise Spectral Density



(C). Typical Shape of Elevation Spectral Density

Figure F-3. Significance of Band Limiting on Mean-Square Values

is flat in the total frequency range from f = 0 to f = + ∞ Hz. The mean square (MS) value of the signal can be calculated from the area under the spectral density curve. Thus, for pure white noise, the MS (and therefore the RMS) is unbounded. This case is of academic interest only for illustration and never occurs in practice.

More realistically, raw data are limited in frequency content in some band from f_L to f_H as shown in Figure F-3(B). The band limiting is usually caused by instrumentation limitations or by digitizing rate and total time span, or it may be a quality of the data itself. Hence, any realistic random raw data trace will have a bounded RMS value since the area under the spectrum is bounded. Further filtering operations or equivalently, removing data points, will move the frequency bounds inward to, for example, f_L and f_H. Since the area under the spectrum is decreased when this is done, the RMS level is also decreased.

In general, a raw data trace, such as a runway profile, will have an upper bound RMS level of no particular significance. Filtering out wavelengths of no interest in assessing aircraft vibration will lower the RMS level of the residual signal in proportion to the square root of the area under the spectral density curve. Actually, runway profile elevation data appears more like red noise than white noise, as shown in Figure F-3 (C), where the amplitude increases as frequency decreases. However, the above illustration is still applicable.

RATIONALE FOR COMPARING PCI WITH RMS

The generation of a PCI value for a segment of pavement is a comprehensive technique for reducing subjective judgment to quantitative pavement structural condition information. The problem should be addressed as to whether band-limited RMS values are correlated with PCI values. If significant correlation exists, then one may be used as an independent variable to predict the other as a dependent variable. On the other hand, if RMS and PCI are found to be uncorrelated, this condition would warrant the following two conclusions:

1. RMS cannot be used to assess pavement structural condition.

2. PCI cannot be used to assess vehicle ride quality.

The degree of dependence or correlation between PCI and RMS can be measured by conventional statistical correlation obtained through regression analysis. Poor correlation must be expected if the roughness is built in to a new pavement, which actually occurred at Washington National Airport as mentioned in the introduction to this appendix. If the roughness occurs from normal wear, however, good correlation may result.

The fact that the PCI is calculated from a nonlinear combination of the dependent distress variables suggests that correlation with RMS may exist with the variables themselves rather than with the PCI alone. Some variables contributing to the PCI are obviously independent of profile

roughness and may reduce correlation significantly. Also, some variables are obviously a direct cause or result of profile roughness and may show high correlation with RMS. The correlation of both the individual and specific collective distress variables with RMS can be obtained by multiple linear regression.

INPUT DATA FOR CORRELATION STUDIES

PCI and RMS data were collected for runway 12/30 at Ellsworth Air Force Base and for runways 17C/35C and 17R/35L at Vance Air Force Base. Pavement lengths were subdivided into features and segments within features.

Table F-1 lists the pertinent feature information for this runway, consisting of feature length, surface material, segment subdivisions, independent variable deduct values contributing to the PCI, and the PCI ratings. Table F-1(A) lists the concrete features, and Table F-1(B) lists the asphalt features for Ellsworth. Tables F-1(C) through F-1(F) list the same information respectively for each of the two runways of Vance.

Tables F-2(A) through F-2(C) show the band-limited RMS data for each runway segment studied. The short wavelength is the Nyquist wavelength of 4.0 feet in all cases. The long wavelength limit is varied at selected values from 400 feet down to 10 feet. It is unlikely that the RMS values for the cases where the upper wavelength limits are 25 feet and 10 feet are significant indicators of roughness for any type of aircraft. These values were obtained solely because of possible correlation within a local visible range of the team of investigators during the evaluation of the PCI variables.

Linear multiple correlation and regression analysis was done with all of the above data, using the computer program REGRESSION from the Statistical Package for the Social Sciences (SPSS).[5] The band-limited RMS value was used as the dependent variable in each case. The model regression equation appears as:

$$y = a_o + a_1x_1 + a_2x_2 + \dots + a_nx_n \qquad \text{(F-5)}$$

where

y = band-limited RMS value

a_o = regression constant (zero intercept)

n = number of case independent variables

[5]Nei, N. H., et. al., Statistical Package for the Social Sciences, (New York: McGraw-Hill Book Company, 1975).

TABLE F-(A). ELLSWORTH (RCA) 12/

Feature	Feature Length	Material	Segment	Segment Length	PCI	3L		5M	5H	6L	6M	10L	13L	14L	14M
19	500	C	1	125	85.0		2.0					13.5			
			2	125	78.0	4.9	2.0			0.6		11.0	1.5	2.2	
			3	125	75.0		2.0				2.7	17.0			
			4	125	78.0		2.0				2.7	12.9	2.1		
13	500	C	1	125	82.0		2.0					9.4	1.0		
			2	125	88.0			7.0				8.2			
			3	125	76.0			7.0		0.6	2.7	9.4	1.0		
			4	125	72.0				12.0			6.6		2.2	9.5
23	500	C	1	125	80.0					2.2	2.7		1.5		
			2	125	92.0					2.2		2.1	2.1		
			3	125	90.0		2.0	7.0					1.0		
			4	125	78.0		2.0			1.1				2.2	

TABLE F-1(B). ELLSWORTH (RCA) 12/

Feature	Feature Length	Material	Segment	Segment Length	PCI	1L	5L	7L	7M	7H	8L	8M	9L	10L	10M
8		A	1		57.0			2.1	37.5					3.0	
			4		70.0			9.5	30.2	1.2				2.0	
			7		75.0			12.3	20.5	3.5				4.1	
			10		73.0			14.0	18.5		3.3	9.5		3.1	
			13		64.0			9.5	22.5	8.2	6.1				
			16		58.0	14.4		11.5	18.5			11.5			
			19		79.0		1.5	16.1			3.3				
8W		A	1		70.0			11.0	12.9						13.1
			4		74.0			6.0	26.2			8.0		2.5	
			7		73.0			9.5	19.7	3.5	2.8			3.9	
			10		86.0			10.5	8.9		2.5				8.4
			13		81.0			10.6	15.3		3.9				6.3
			16		74.0			7.2	24.5		5.1			2.0	7.0
			19		84.0			11.0	6.9		3.9			2.2	
9		A	1		90.0			7.6			8.7				
			2		83.0		1.1	7.4	17.1						
			3		86.0		0.2	9.5	14.3						
			4		71.0				28.8						
			5		81.0			7.6	19.1						
			6		89.0			10.8							
			7		85.0			8.6	15.1						
39		A	1		86.0			3.4	0.7		5.6				
			7		91.0			4.0							
			13		88.0						12.3				
			19		92.0						6.4				
			25		89.0			5.0							
			31		92.0						7.8	6.5			
			37		93.0						3.1				
			43		85.0									0.2	
			49		95.0						5.5				
			55		98.0			1.7							
			61		81.0						2.8				
			67		92.0		7.9				6.1				
			73		84.0			1.1			6.0				
			79		86.0				11.7						
			85		81.0	14.7						15.1	2.0		

(The reverse

TABLE F-(A). ELLSWORTH (RCA) 12/30, CONCRETE FEATURES

Segment Length	PCI	3L		5M	5H	6L	6M	10L	13L	14L	14M	14H	15L	15M	15H
125	85.0		2.0					13.5							
125	78.0	4.9	2.0			0.6		11.0	1.5	2.2					
125	75.0		2.0				2.7	17.0						3.3	
125	78.0		2.0				2.7	12.9	2.1				1.9		
125	82.0		2.0					9.4	1.0				1.9	3.3	
125	88.0			7.0				8.2							
125	76.0			7.0		0.6	2.7	9.4	1.0				5.5	3.3	5.1
125	72.0				12.0			6.6		2.2	9.5				10.8
125	80.0					2.2	2.7		1.5			13.2			
125	92.0					2.2		2.1	2.1				1.9		
125	90.0		2.0	7.0					1.0						
125	78.0		2.0			1.1				2.2		13.2		3.3	

TABLE F-1(B). ELLSWORTH (RCA) 12/30, ASPHALT FEATURES

Segment Length	PCI	1L	5L	7L	7M	7H	8L	8M	9L	10L	10M	12L	12M	12H	13L
	57.0			2.1	37.5					3.0					
	70.0			9.5	30.2	1.2				2.0					
	75.0			12.3	20.5	3.5				4.1					
	73.0			14.0	18.5		3.3	9.5		3.1					
	64.0			9.5	22.5	8.2	6.1								
	58.0	14.4		11.5	18.5			11.5				24.3			
	79.0		1.5	16.1			3.3								
	70.0			11.0	12.9						13.1	15.0		9.0	23.5
	74.0			6.0	26.2			8.0		2.5		8.8			
	73.0			9.5	19.7	3.5	2.8			3.9		9.9			
	86.0			10.5	8.9		2.5				8.4	8.9			
	81.0			10.6	15.3		3.9				6.3	8.8			
	74.0			7.2	24.5		5.1			2.0	7.0	8.8			
	84.0			11.0	6.9		3.9			2.2		9.4			
	90.0			7.6			8.7					4.4			
	83.0		1.1	7.4	17.1							2.2			
	86.0		0.2	9.5	14.3										
	71.0				28.8										
	81.0			7.6	19.1										
	89.0			10.8											
	85.0			8.6	15.1										
	86.0			3.4	0.7		5.6					4.4			
	91.0			4.0								4.9			
	88.0						12.3								
	92.0						6.4					8.2			
	89.0			5.0								7.1			9.3
	92.0						7.8	6.5							
	93.0						3.1					4.1			
	85.0									0.2		3.7			11.5
	95.0						5.5								
	98.0			1.7								0.7			
	81.0						2.8					4.4			11.5
	92.0		7.9				6.1								
	84.0			1.1			6.0					2.3			16.4
	86.0				11.7								14.0		
	81.0	14.7						15.1	2.0						

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TABLE F-1(C). VANCE (END) 17R/35L, CONCRETE FEATURES

Feature	Feature Length	Material	Segment	Segment Length	PCI	3L	3M	5M	6L	6H	7L	1
R28		C	10	175	43	21.2	28.2	7.0		10.3	6.0	17
	1300		9	125	53	22.0	19.0	7.0				15
			7	125	66	22.0		7.0	0.6			15
			5	125	59	22.0	11.6	7.0	1.1			17
			4	125	45	22.0	31.8	7.0	1.1			15
			3	125	40	22.0	31.8	7.0	1.6			17
			1	125	64	15.5	11.6	7.0				17
R5C&R6C		C	23	150	42	22.0	11.6	7.0	1.6			16
	2925		22	125	70	22.0		7.0				11
			20	125	50	22.0	28.2	7.0	0.6			12
			18	125	69	22.0		7.0	0.6			12
			16	125	63	21.8	11.6	7.0				12
			14	125	62	20.2	11.6	7.0				12
			12	125	68	19.0		7.0				2
			10	125	70	15.5		7.0				12
			8	125	60	21.2	24.0	7.0				17
			6	125	48	22.0	31.8	7.0				12
			4	125	47	22.0	28.2	7.0				17
			2	125	41	21.8	38.0	7.0				17
R7B		C	8	125	41	21.8	38.0	7.0	1.1			17
	1000		6	125	41	19.0	40.5	7.0	0.6			17
			4	125	37	18.0	50.3	7.0				17
			2	125	54	21.8	19.0	7.0				17
			1	125	69	15.5		7.0				17

TABLE F-1(D). VANCE (END) 17R/35L, ASPHALT FEATURES

Feature	Feature Length	Material	Segment	Segment Length	PCI	7L	8L	8M	10L	12L
R4C		A	13	50	90	5.0	5.5			
			12	50	93	7.0	5.9			
			11	50	93	0.7	6.3			
			10	50	92	1.8	6.1	8.0		
			9	50	98	1.7				
			8	50	89	8.2	2.8			
			7	50	95	2.1	3.0			
			6	50	91	8.9	5.5			
			5	50	91	8.6	5.9			
			4	50	92	8.0	5.9			
			3	50	91	9.4	6.1			3.5
			2	50	89	8.8	7.1		10.7	
			1	50	87	2.7	3.0			7.5

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TABLE F-1(C). VANCE (END) 17R/35L, CONCRETE FEATURES

al	Segment	Segment Length	PCI	3L	3M	5M	6L	6H	7L	10L	14L	15L
	10	175	43	21.2	28.2	7.0		10.3	6.0	17.0		
	9	125	53	22.0	19.0	7.0				15.7	2.2	
	7	125	66	22.0		7.0	0.6			15.7		
	5	125	59	22.0	11.6	7.0	1.1			17.0		
	4	125	45	22.0	31.8	7.0	1.1			15.7		
	3	125	40	22.0	31.8	7.0	1.6			17.0		
	1	125	64	15.5	11.6	7.0				17.0		
	23	150	42	22.0	11.6	7.0	1.6			16.5		1.9
	22	125	70	22.0		7.0				11.0		
	20	125	50	22.0	28.2	7.0	0.6			12.2		
	18	125	69	22.0		7.0	0.6			12.2		
	16	125	63	21.8	11.6	7.0				12.2		
	14	125	62	20.2	11.6	7.0				12.9		
	12	125	68	19.0		7.0				2.1		3.7
	10	125	70	15.5		7.0				12.2		
	8	125	60	21.2	24.0	7.0				17.0		
	6	125	48	22.0	31.8	7.0				12.2		
	4	125	47	22.0	28.2	7.0				17.0		
	2	125	41	21.8	38.0	7.0				17.0		
	8	125	41	21.8	38.0	7.0	1.1			17.0		
	6	125	41	19.0	40.5	7.0	0.6			17.0		
	4	125	37	18.0	50.3	7.0				17.0		
	2	125	54	21.8	19.0	7.0				17.0		
	1	125	69	15.5		7.0				17.0	2.2	

TABLE F-1(D). VANCE (END) 17R/35L, ASPHALT FEATURES

e	Material	Segment	Segment Length	PCI	7L	8L	8M	10L	12L
	A	13	50	90	5.0	5.5			
		12	50	93	7.0	5.9			
		11	50	93	0.7	6.3			
		10	50	92	1.8	6.1	8.0		
		9	50	98	1.7				
		8	50	89	8.2	2.8			
		7	50	95	2.1	3.0			
		6	50	91	8.9	5.5			
		5	50	91	8.6	5.9			
		4	50	92	8.0	5.9			
		3	50	91	9.4	6.1			3.5
		2	50	89	8.8	7.1		10.7	
		1	50	87	2.7	3.0			7.5

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TABLE F-1(E). VANCE (END) 17C/35C, CONCRETE FEATURES

Feature	Feature Length	Material	Segment	Segment Length	PCI	3L	3M	4L	4M	5L	5M	6L	6M	7L	10L	13L	14L	15L	15M
R13B		C	7	125	75	11.3				2.0					15.7				
	1000		4	125	68	21.2				2.0		0.6			16.5				
			3	125	69	19.0				2.0					15.7				
			1	125	71	18.0				2.0		0.6			15.7	1.0			
R12C		C	8	125	84			1.8				3.2			9.4	1.9			
	1000		6	125	79	15.5						1.1			7.0	2.9			
			4	125	75	17.0						4.0			2.1	1.5			
			2	125	61	20.2	11.6					3.2		3.1	14.5				
R11C		C	16	80	75	12.1		14.9			7.0								
	1300		14	80	72	12.1		17.2			7.0	1.8							
			12	80	75			17.8	3.1		7.0	0.5							2.3
			10	80	77			17.5			7.0	1.0						3.1	
			8	80	74	10.0		18.0			7.0	0.5							
			6	80	78			17.0			7.0	0.5						3.1	
			4	80	66	10.0		17.2	8.6		7.0	1.0				1.3	4.1		
			2	80	76	4.1		15.6			7.0	1.2	2.2						
R10B		C	13	80	64	22.0		18.2		2.0		0.5				1.0			
	1000		11	80	84			5.5	3.1	2.0		0.5			3.2			1.5	
			9	80	76			14.3	3.1	2.0		1.0	2.2					1.5	
			7	80	79			16.1	3.1	2.0									
			5	80	79			15.6	3.1	2.0		0.5							
			3	80	79			15.6	3.1	2.0		0.5							

TABLE F-1(F). VANCE (END) 17C/35C, ASPHALT FEATURES

Feature	Feature Length	Material	Segment	Segment Length	PCI	3L	3M	8L	8M	10L	5L
RENSC		A	98	50	69	30.9		5.8		8.8	
	4900		92	50	66	33.6		7.5			
			86	50	63	32.9		4.1			
			80	50	65	35.2		6.9			0.3
			74	50	67	33.2		8.7			
			68	50	76	23.6		13.7			
			62	50	65	32.3		3.0			
			56	50	72	27.3		17.0	6.2		
			50	50	68	25.1		23.2	6.2		
			44	50	80			20.4	6.0		
			38	50	81			19.2			
			32	50	75	8.0		25.4			
			26	50	84	10.8		16.2			
			20	50	81	5.6		19.1	9.5		
			14	50	75		7.9	24.8	5.0		
			8	50	78			22.4	5.9		
			2	50	74	18.9		22.1			

TABLE F-2(A). ELLSWORTH (RCA) RUNWAY 12/30, SHEET 1
BAND LIMITED RMS VALUES (INCHES)

Surface Material	Feature/ Segment	RMS (INCHES) 400Ft	200Ft	100Ft	50Ft	25Ft	10Ft
Concrete	19/1	0.3779	0.2630	0.1707	0.1063	0.0719	0.0336
Concrete	2	0.3091	0.2638	0.1556	0.1080	0.0717	0.0336
Concrete	3	0.5140	0.2782	0.1561	0.1019	0.0742	0.0364
Concrete	4	0.1923	0.1521	0.1312	0.1026	0.0659	0.0315
Concrete	13/1	0.2114	0.1396	0.1154	0.0951	0.0758	0.0427
Concrete	2	0.2272	0.1837	0.1173	0.0853	0.0698	0.0396
Concrete	3	0.1597	0.1401	0.1157	0.0947	0.0631	0.0323
Concrete	4	0.3185	0.2650	0.1482	0.1202	0.0894	0.0467
Concrete	23/1	0.0939	0.0915	0.0814	0.0607	0.0422	0.0311
Concrete	2	0.2006	0.1387	0.0935	0.0704	0.0507	0.0319
Concrete	3	0.1209	0.1301	0.0909	0.0636	0.0458	0.0283
Concrete	4	0.2639	0.1631	0.0697	0.0528	0.0346	0.0205
Asphalt	8/1	0.2814	0.3172	0.1264	0.0714	0.0380	0.0210
Asphalt	4	0.2159	0.0836	0.0604	0.0458	0.0303	0.0200
Asphalt	7	0.1565	0.1165	0.0975	0.0437	0.0328	0.0197
Asphalt	10	0.1126	0.1571	0.0987	0.0521	0.0363	0.0212
Asphalt	13	0.1764	0.1762	0.1161	0.0496	0.0322	0.0242
Asphalt	16	0.1605	0.1755	0.1303	0.0607	0.0335	0.0204
Asphalt	19	0.2616	0.2587	0.1507	0.0837	0.0577	0.0391
Asphalt	8W/1	0.2373	0.2559	0.0753	0.0472	0.0340	0.0269
Asphalt	4	0.1757	0.1822	0.1214	0.0510	0.0341	0.0213
Asphalt	7	0.1495	0.1406	0.1074	0.0819	0.0582	0.0242
Asphalt	10	0.1731	0.1483	0.1355	0.0394	0.0268	0.0212
Asphalt	13	0.1917	0.1713	0.1531	0.0786	0.0487	0.0270
Asphalt	16	0.1147	0.0909	0.0664	0.0459	0.0366	0.0281
Asphalt	19	0.1781	0.2345	0.1279	0.0662	0.0341	0.0215

TABLE F-2(A). ELLSWORTH (RCA) RUNWAY 12/30, SHEET 2
BAND LIMITED RMS VALUES (INCHES) (CONCLUDED)

Surface Material	Feature/ Segment	RMS (INCHES) 400Ft	200Ft	100Ft	50Ft	25Ft	10Ft
Asphalt	9/1	0.3445	0.2315	0.1459	0.0846	0.0430	0.0202
Asphalt	2	0.1724	0.1462	0.1085	0.0607	0.0397	0.0273
Asphalt	3	0.1627	0.1486	0.1165	0.0587	0.0306	0.0178
Asphalt	4	0.1710	0.1258	0.0949	0.0553	0.0309	0.0175
Asphalt	5	0.1602	0.1417	0.1143	0.0601	0.0366	0.0277
Asphalt	6	0.1455	0.1252	0.0862	0.0470	0.0312	0.0180
Asphalt	7	0.1198	0.0966	0.0776	0.0498	0.0256	0.0158
Asphalt	39/1	0.1726	0.1408	0.1057	0.0477	0.0281	0.0187
Asphalt	7	0.0907	0.0876	0.0715	0.0522	0.0312	0.0206
Asphalt	13	0.1760	0.1464	0.1203	0.0751	0.0384	0.0215
Asphalt	19	0.1859	0.1203	0.0858	0.0541	0.0356	0.0229
Asphalt	25	0.2316	0.2111	0.1724	0.1080	0.0616	0.0349
Asphalt	31	0.1265	0.1312	0.0644	0.0397	0.0308	0.0202
Asphalt	37	0.0926	0.0890	0.0711	0.0419	0.0302	0.0212
Asphalt	43	0.1219	0.1219	0.1117	0.0826	0.0425	0.0207
Asphalt	49	0.0927	0.0857	0.0720	0.0541	0.0315	0.0218
Asphalt	55	0.0872	0.0851	0.0922	0.0600	0.0308	0.0208
Asphalt	61	0.2042	0.1703	0.1214	0.0708	0.0407	0.0261
Asphalt	67	0.1057	0.1100	0.0823	0.0482	0.0325	0.0248
Asphalt	73	0.0729	0.0730	0.0694	0.0544	0.0332	0.0234
Asphalt	79	0.1216	0.1161	0.0904	0.0653	0.0449	0.0285
Asphalt	85	0.1388	0.1349	0.1064	0.0756	0.0472	0.0363

TABLE F-2(B). VANCE RUNWAY 17R/35L
BAND LIMITED RMS VALUES (INCHES)

Surface Material	Feature/ Segment	RMS (INCHES) 400Ft	200Ft	100Ft	50Ft	25Ft	10Ft
Concrete	R2B/10	0.1516	0.1319	0.1155	0.0750	0.0432	0.0263
Concrete	9	0.1956	0.1689	0.1117	0.0674	0.0413	0.0263
Concrete	7	0.1364	0.1151	0.0748	0.0608	0.0414	0.0237
Concrete	5	0.2663	0.2267	0.1480	0.0900	0.0455	0.0255
Concrete	4	0.1452	0.1407	0.1038	0.0705	0.0451	0.0244
Concrete	3	0.2098	0.1822	0.1152	0.0744	0.0488	0.0256
Concrete	1	0.5002	0.2994	0.1288	0.0676	0.0435	0.0246
Asphalt	R4C/13	0.0856	0.0922	0.0545	0.0463	0.0298	0.0182
Asphalt	12	0.1078	0.0548	0.0512	0.0433	0.0282	0.0177
Asphalt	11	0.1455	0.0807	0.0471	0.0396	0.0233	0.0156
Asphalt	10	0.0739	0.0550	0.0617	0.0394	0.0267	0.0157
Asphalt	9	0.0908	0.0741	0.0561	0.0395	0.0265	0.0132
Asphalt	8	0.0706	0.0888	0.0728	0.0436	0.0252	0.0127
Asphalt	7	0.0731	0.0533	0.0461	0.0389	0.0290	0.0196
Asphalt	6	0.0526	0.0541	0.0459	0.0401	0.0277	0.0129
Asphalt	5	0.1001	0.0964	0.0601	0.0468	0.0290	0.0118
Asphalt	4	0.1128	0.0913	0.0660	0.0468	0.0312	0.0202
Asphalt	3	0.0855	0.0939	0.0646	0.0420	0.0291	0.0207
Asphalt	2	0.1078	0.0932	0.0536	0.0389	0.0290	0.0206
Asphalt	1	0.1361	0.1417	0.1096	0.0838	0.0440	0.0240
Concrete	R5C & R6C/23	0.4439	0.3425	0.2182	0.1111	0.0574	0.0255
Concrete	22	0.2247	0.1687	0.1169	0.0851	0.0517	0.0235
Concrete	20	0.1451	0.1398	0.1220	0.0765	0.0511	0.0301
Concrete	18	0.2315	0.2272	0.1978	0.1088	0.0500	0.0236
Concrete	16	0.1235	0.1113	0.0977	0.0815	0.0497	0.0257
Concrete	14	0.1682	0.1737	0.0987	0.0718	0.0472	0.0256
Concrete	12	0.1976	0.1130	0.0809	0.0661	0.0432	0.0198
Concrete	10	0.2480	0.1659	0.1174	0.0733	0.0384	0.0198
Concrete	8	0.1528	0.1166	0.0800	0.0527	0.0310	0.0195
Concrete	6	0.0955	0.0844	0.0671	0.0527	0.0356	0.0210
Concrete	4	0.0854	0.0861	0.0695	0.0497	0.0369	0.0241
Concrete	2	0.1796	0.1778	0.1194	0.0650	0.0396	0.0213
Concrete	R7B/ 8	0.0928	0.1012	0.0881	0.0691	0.0388	0.0212
Concrete	6	0.1135	0.0944	0.0897	0.0589	0.0371	0.0233
Concrete	4	0.1076	0.1060	0.0888	0.0609	0.0426	0.0319
Concrete	2	0.1755	0.1750	0.1066	0.0648	0.0428	0.0218
Concrete	1	0.1938	0.1840	0.1211	0.0635	0.0375	0.0205

TABLE F-2(C). VANCE RUNWAY 17C/35C
BAND LIMITED RMS VALUES (INCHES)

Surface Material	Feature/ Segment	RMS (INCHES)					
		400Ft	200Ft	100Ft	50Ft	25Ft	10Ft
Concrete	R13B/ 7	0.2777	0.1096	0.0739	0.0535	0.0347	0.0250
Concrete	4	0.1929	0.1168	0.0659	0.0466	0.0314	0.0203
Concrete	3	0.1721	0.1430	0.0684	0.0456	0.0340	0.0201
Concrete	1	0.1802	0.1442	0.0725	0.0518	0.0308	0.0187
Asphalt	RENSC/						
	98	0.2054	0.1785	0.0863	0.0487	0.0267	0.0192
Asphalt	92	0.0871	0.0713	0.0754	0.0539	0.0365	0.0205
Asphalt	86	0.1349	0.1198	0.0771	0.0556	0.0436	0.0330
Asphalt	80	0.0517	0.0510	0.0475	0.0343	0.0324	0.0237
Asphalt	74	0.1572	0.1636	0.0998	0.0733	0.0381	0.0288
Asphalt	68	0.0742	0.0742	0.0790	0.0532	0.0437	0.0324
Asphalt	62	0.0951	0.0910	0.0958	0.0612	0.0442	0.0221
Asphalt	56	0.2260	0.1936	0.1222	0.0404	0.0366	0.0184
Asphalt	50	0.0559	0.0376	0.0440	0.0273	0.0192	0.0109
Asphalt	44	0.1877	0.1576	0.1157	0.0613	0.0335	0.0162
Asphalt	38	0.2529	0.1389	0.1105	0.0924	0.0550	0.0322
Asphalt	32	0.1722	0.1617	0.0969	0.0859	0.0521	0.0211
Asphalt	26	0.3642	0.3481	0.2787	0.1679	0.0549	0.0381
Asphalt	20	0.1271	0.0878	0.0801	0.0480	0.0302	0.0166
Asphalt	14	0.6043	0.5535	0.2880	0.1723	0.0971	0.0176
Asphalt	8	0.3137	0.2403	0.1801	0.1424	0.0987	0.0431
Asphalt	2	0.1740	0.1236	0.1683	0.0876	0.0341	0.0199
Concrete	R12C/ 8	0.2583	0.2098	0.1846	0.0960	0.0407	0.0215
Concrete	6	0.1802	0.1376	0.0846	0.0596	0.0501	0.0254
Concrete	4	0.2415	0.2098	0.1614	0.0785	0.0343	0.0200
Concrete	2	0.1703	0.1650	0.1636	0.0915	0.0520	0.0342
Concrete	R11C/16	0.1474	0.1365	0.1461	0.0822	0.0573	0.0184
Concrete	14	0.4661	0.3244	0.1107	0.0909	0.0517	0.0263
Concrete	12	0.2024	0.1803	0.1663	0.0410	0.0654	0.0358
Concrete	10	0.1395	0.1224	0.1094	0.0715	0.0402	0.0181
Concrete	8	0.1940	0.1969	0.1378	0.0680	0.0351	0.0165
Concrete	6	0.1356	0.1123	0.0849	0.0667	0.0401	0.0282
Concrete	4	0.1478	0.0907	0.0731	0.0624	0.0356	0.0233
Concrete	2	0.0879	0.1089	0.0774	0.0336	0.0254	0.0200
Concrete	R10B/13	0.1591	0.1380	0.0894	0.0934	0.0756	0.0409
Concrete	11	0.1553	0.1622	0.0932	0.0563	0.0464	0.0277
Concrete	9	0.1577	0.1238	0.0791	0.0605	0.0451	0.0278
Concrete	7	0.1023	0.0971	0.0834	0.0515	0.0399	0.0234
Concrete	5	0.0941	0.0800	0.0741	0.0490	0.0426	0.0310
Concrete	3	0.1021	0.1098	0.1024	0.0870	0.0442	0.0196

a_i, $i=1,\ldots.n$ = optimum constants generated by the program

x_i, $i=1,\ldots..n$ = independent variable deduct values, or PCI alone for $n = 1$.

The program generated the optimum constants, the coefficient of determination, the correlation coefficient, and a complete analysis of variance for the case variables. The dependent variables (y) were taken from Table F-2, and the independent variables (x_i, $i = 1,\ldots.n$) were taken from Table F-1. The following types of correlation and regression were made:

1. Simple correlation and regression: Band-limited RMS with each distress deduct value contributing to the PCI rating.

2. Linear multiple correlation and regression: Band-limited RMS with a linear combination of all appropriate distress deduct values.

3. Simple correlation and regression: Band-limited RMS with PCI only.

4. Simple correlation and regression: Feature-averaged band-limited RMS with PCI only.

The results of these studies will be discussed in the following section.

RESULTS OF STATISTICAL ANALYSIS

1. Simple Correlation and Regression: RMS with Independent Distress Deduct Values

There was no significant correlation in the data between segment RMS and each distress type considered separately. In several cases, correlation was apparently strong, but closer investigation revealed that only one or two data points for the distress variables existed, which happened to be in the correct trend. This general result was obtained for both the concrete and asphalt features.

2. Linear Multiple Correlation and Regression: RMS with Combined Distress Deduct Values

Table F-3 shows the results of correlating band-limited RMS with a linear combination of the distress deduct values considered as independent variables. For the concrete features at Ellsworth (Table F-3, sheet 2), there were more distress types than data points, which prohibited the multiple correlation. Hence only the data from the asphalt features were analyzed in this manner for Ellsworth. The upper band of the RMS value is given in the second column of Table F-3, so that the filtering effects can be seen. The third column gives the ordered distress types, as determined from regression and analysis of variance. The coefficient of determination (R^2) is shown in the fifth column. The sixth and seventh columns show the F values and corresponding significance levels from the analysis of variance.

TABLE F-3. CORRELATION AND REGRESSION SUMMARY, SEGMENT ANALYSIS

Runway/ Material	y (Upper Band of RMS)	x_i Ordered Independent Variables	Multiple R	R^2	Overall F	Signifi- cance
RCA 12/30 Asphalt	400 feet	1L, 7L, 5L, 12H, 12M, 7H, 8L, 10L, 12L, 13L, 7M, 8M, 10M, 9L	0.6446	0.4155	1.0664	0.435
	200 feet		0.6401	0.4097	1.0412	0.454
	100 feet		0.6132	0.3761	0.9041	0.568
	50 feet		0.6379	0.4069	1.0289	0.464
	25 feet		0.6017	0.3621	0.8513	0.614
	10 feet		0.6910	0.4775	1.3710	0.250
END 17R/35L Asphalt	400 feet	7L, 12L, 10L, 8M, 8L	0.7806	0.6094	2.1849	0.168
	200 feet		0.8001	0.6402	2.4910	0.133
	100 feet		0.8884	0.7892	5.2438	0.026
	50 feet		0.8758	0.7671	4.6132	0.035
	25 feet		0.3769	0.1421	0.2318	0.937
	10 feet		0.7747	0.6002	2.1017	0.180
END 17C/35C Asphalt	400 feet	3L, 10L, 5L, 3M, 8M, 8L	0.8858	0.7846	6.0710	0.007
	200 feet		0.8620	0.7431	4.8216	0.015
	100 feet		0.7549	0.5699	2.2086	0.128
	50 feet		0.8202	0.6727	3.4257	0.042
	25 feet		0.7806	0.6093	2.5989	0.088
	10 feet		0.6602	0.4359	1.2877	0.344
RCA 12/30 Concrete	400 feet	Insufficient Data for Linear Multiple Correlation				
	200 feet					
	100 feet					
	50 feet					
	25 feet					
	25 feet					
	10 feet					

TABLE F-3. CORRELATION AND REGRESSION SUMMARY, SEGMENT ANALYSIS (CONTINUED)

Runway/ Material	y (Upper Band of RMS)	x_i Ordered Independent Variables	Multiple R	R^2	Overall F	Significance
END 17R/35L Concrete	400 feet	3L,6H,15L,14L,3M,6L,10L	0.7388	0.5458	2.7471	0.045
	200 feet		0.7261	0.5272	2.5485	0.057
	100 feet		0.6525	0.4257	1.6944	0.181
	50 feet		0.7368	0.5428	2.7138	0.047
	25 feet		0.6440	0.4147	1.6197	0.200
	10 feet		0.4300	0.1849	0.5185	0.808
END 17C/35C Concrete	400 feet	3L,14L,6L,15M,6M,5M,7L,15L,13L,10L,4L,4M,5L	0.7219	0.5212	0.6699	0.750
	200 feet		0.8429	0.7104	1.5098	0.284
	100 feet		0.9012	0.8122	2.6605	0.085
	50 feet		0.8287	0.6868	1.3493	0.344
	25 feet		0.8477	0.7185	1.5708	0.265
	10 feet		0.8367	0.7001	1.4367	0.310
RCA 12/30 Asphalt	400 feet	PCI only	0.3454	0.1193	4.6068	0.039
	200 feet		0.4572	0.2090	8.9855	0.005
	100 feet		0.1677	0.0281	0.9841	0.328
	50 feet		0.0085	0.0001	0.0025	0.961
	25 feet		0.0714	0.0051	0.1743	0.679
	10 feet		0.0345	0.0012	0.0404	0.842
END 17R/35L Asphalt	400 feet	PCI only	0.1452	0.0211	0.2370	0.636
	200 feet		0.6338	0.4017	7.3851	0.020
	100 feet		0.5805	0.3370	5.5902	0.038
	50 feet		0.5568	0.3100	4.9424	0.048
	25 feet		0.2393	0.0572	0.6680	0.431
	10 feet		0.3466	0.1201	1.5015	0.246

TABLE F-3. CORRELATION AND REGRESSION SUMMARY, SEGMENT ANALYSIS (CONCLUDED)

Runway/ Material	y (Upper Band of RMS)	x_i Ordered Independent Variables	Multiple R	R^2	Overall F	Significance
END 17C/35C Asphalt	400 feet	PCI only	0.4738	0.2245	4.3424	0.055
	200 feet		0.3873	0.1500	2.6477	0.125
	100 feet		0.5333	0.2844	5.9613	0.027
	50 feet		0.5391	0.2907	6.1462	0.026
	25 feet		0.3448	0.1189	2.0241	0.175
	10 feet		0.2351	0.0552	0.8772	0.364
RCA 12/30 Concrete	400 feet	PCI only	0.3720	0.1384	1.6066	0.234
	200 feet		0.3888	0.1511	1.7805	0.212
	100 feet		0.3427	0.1174	1.3305	0.276
	50 feet		0.4852	0.2354	3.0786	0.110
	25 feet		0.3807	0.1449	1.6950	0.222
	10 feet		0.2022	0.0409	0.4264	0.528
END 17R/35L Concrete	400 feet	PCI only	0.2652	0.0703	1.6639	0.210
	200 feet		0.1711	0.0293	0.6636	0.424
	100 feet		0.0832	0.0069	0.1534	0.699
	50 feet		0.1712	0.0293	0.6646	0.424
	25 feet		0.0559	0.0031	0.0690	0.795
	10 feet		0.3810	0.1452	3.7356	0.066
END 17C/35C Concrete	400 feet	PCI only	0.1059	0.0112	0.2268	0.639
	200 feet		0.0234	0.0006	0.0109	0.918
	100 feet		0.0877	0.0077	0.1550	0.698
	50 feet		0.1186	0.0141	0.2852	0.599
	25 feet		0.1680	0.0282	0.5805	0.455
	10 feet		0.2720	0.0740	1.5985	0.221

For Vance, the linear multiple correlation shows values of R^2 usually well above 0.50 for upper band wavelength limits of 50 feet or greater. This result appears for both concrete and asphalt features at Vance. At Ellsworth, however, there was insufficient data to perform the regression for the concrete features, and the asphalt features exhibited values of R^2 less than 0.50. Nevertheless, there is evidence in these results that RMS can be predicted when individual distress factors are used in multiple linear regression. That is, it appears plausible that a regression equation can be developed to predict RMS as a function of a linear combination of distresses. However, the development of a universal equation that can be used for estimating RMS for any particular feature requires obtaining extensive additional data.

3. Simple Correlation and Regression: RMS with PCI

Table F-3 also shows the results of simple linear correlation and regression between RMS and PCI. It is recalled that the PCI is a nonlinear combination of distress-type deduct values; hence, the comparison is different from that discussed above for linear multiple correlation. The R^2 coefficients are somewhat smaller in this case than those for multiple correlation. Therefore, it must be concluded that the distress deduct values which do not affect roughness serve to reduce correlation with RMS.

4. Simple Correlation and Regression: Average Feature RMS with PCI

As a final study, the band-limited RMS and PCI values were averaged for segments within features to determine if significant correlation existed on the larger scale for overall feature properties. Table F-4 shows the averaged RMS and PCI values for the concrete and asphalt features. Table F-5 shows the resulting correlation and regression summary for the average feature properties in the same format as Table F-3.

Asphalt feature correlation appears significant for upper band wavelength limits from 100 feet to 400 feet. This correlation is considerably better than that from individual segments discussed above. However, the same result is not obtained for average concrete feature properties, in which the correlation is poor in both areas. The two best cases for the asphalt features are shown plotted (RMS versus PCI) in Figure F-4. Note that only six data points are available (i.e., only six asphalt features from both airfields were studied); hence, more data should be analyzed before firm conclusions can be made.

CONCLUSIONS

The results of three studies show significant correlation between RMS and a linear combination of distress deduct values as in multiple linear regression. This means that it is possible to form a mathematical equation using RMS as the dependent variable and the distress deduct values as independent variables in some linear (and possibly an improved nonlinear) combination. However, the data scatter--or, more formally, the statistical confidence bands--may be wide around the curve generated

TABLE F-4. FEATURE AVERAGED PCI AND RMS

Runway	Feature	Material	Avg. PCI	Averaged RMS (inches) 400 Feet	200 Feet	100 Feet	50 Feet	25 Feet	10 Feet
RCA 12/30	8	ASPH	68.0	0.1915	0.1981	0.1147	0.0597	0.0383	0.0245
	8W	ASPH	77.4	0.1777	0.1825	0.1160	0.0606	0.0402	0.0245
	9	ASPH	83.5	0.1893	0.1502	0.1083	0.0605	0.0344	0.0211
	39	ASPH	88.9	0.1426	0.1267	0.0997	0.0582	0.0383	0.0247
END 17R/35L	R4C	ASPH	91.6	0.0989	0.0857	0.0628	0.0467	0.0295	0.0175
END 17C/35C	RENSC	ASPH	72.9	0.2346	0.2046	0.1386	0.0080	0.0504	0.0258
RCA 12/30	19	CONC	79.0	0.3672	0.2375	0.1540	0.1047	0.0710	0.0338
	13	CONC	79.5	0.2362	0.1891	0.1249	0.0996	0.0752	0.0407
	23	CONC	85.0	0.1826	0.1334	0.0844	0.0622	0.0437	0.0283
END 17R/35L	R2B	CONC	53.3	0.2580	0.1902	0.1159	0.0727	0.0442	0.0252
	R5C&R6C	CONC	57.5	0.2118	0.1731	0.1247	0.0766	0.0450	0.0235
	R7B	CONC	48.4	0.1424	0.1384	0.0997	0.0635	0.0398	0.0241
END 17C/35C	R13B	CONC	70.8	0.2100	0.1293	0.0702	0.0495	0.0328	0.0211
	R12C	CONC	74.8	0.2159	0.2143	0.1533	0.0826	0.0449	0.0259
	R11C	CONC	74.1	0.2194	0.1742	0.1177	0.0729	0.0456	0.0241
	R10B	CONC	76.8	0.1317	0.1215	0.0874	0.0685	0.0504	0.0292

TABLE F-5. CORRELATION AND REGRESSION SUMMARY, FEATURE ANALYSIS

Runway/ Material	y (Upper Band of RMS) (feet)	x_i Ordered Independent Variables	Multiple R	R^2	Overall F	Significance
All, Asphalt	400	Feature Average PCI (6 features)	0.8111	0.6578	7.6899	0.050
	200		0.9482	0.8991	35.6580	0.004
	100		0.7879	0.6208	6.5477	0.063
	50		0.5874	0.3450	2.1072	0.220
	25		0.6442	0.4150	2.8374	0.167
	10		0.6715	0.4509	3.2846	0.144
All, Concrete	400	Feature Average PCI (10 features)	0.1952	0.0381	0.3169	0.589
	200		0.0952	0.0091	0.0731	0.794
	100		0.0504	0.0025	0.0203	0.890
	50		0.2873	0.0825	0.7197	0.421
	25		0.4411	0.1946	1.9323	0.202
	10		0.0675	0.0046	0.0366	0.853

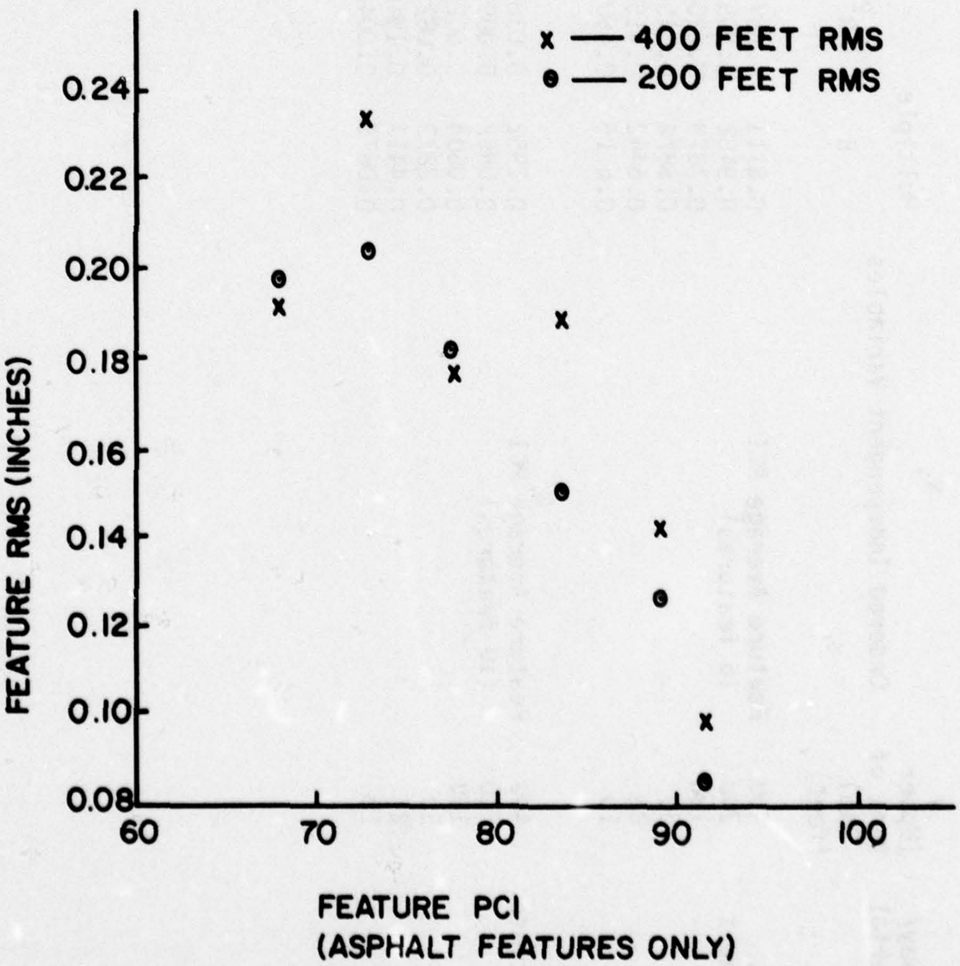

Figure F-4. Best Correlation of Feature RMS with PCI

by this equation. The extent of the confidence bands can be determined only from analyzing more data.

In general, the correlation between RMS and PCI on a segment or sample unit basis was very poor. This is believed to be caused by the influence of distress factors in calculating the PCI which have no influence on surface roughness. When segment properties within features were averaged, however, the correlation for asphalt features appeared significant. Correlation with PCI for concrete features remained very poor. This phenomenon cannot be explained at present.

The range of the PCI values for the data from these airfields was most likely too limited, since pavement condition ranged only from good to excellent. In the case of the Ellsworth data, the roughness reflected by the RMS may have been built in at the time of construction of the pavement. Built-in roughness cannot be reflected in the PCI by the present methods. This problem undoubtedly contributes significantly to the RMS-PCI data scatter and may be controlled only through more restrictive pavement construction specifications.

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APPENDIX G

WORKSHOP PAVEMENT FEATURES

Information on the 37 features evaluated in the feature M&R session of the workshop is given in the following pages. The features are numbered from 1 through 37. They also appear in the order of runways, taxiways, and aprons. The order of presentation during the workshop was in a random fashion.

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY

Environmental: III-A LOW TEMP.

Construction Date: 1955-56

Conditions: SOIL DRY ALL YEAR

Overlay Date: 1970

Pavement Type: ASPHALT

Traffic Area: C

Feature Dimensions: 100 FT x 1150 FT

Primary Aircraft: F-4/CARGO

* PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
[redacted]	1.5 IN.	
[redacted]	4 IN.	
SILTY-GRAVELLY SAND	6 IN.	CBR 100+
SANDY GRAVEL	24 IN.	CBR 100+
SILTY SAND	18 IN.	CBR 20
SUBGRADE SILTY SAND		CBR 8

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	1,504 FT^2	0.13
08	LOW	21,690 FT	1.89
08	MED.	2,441 FT	0.21
12	LOW	106 FT^2	0.01
12	MED.	3,538 FT^2	0.31
12	HIGH	141 FT^2	0.01

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY

Environmental: LOW TEMPERATURE

Construction Date: 1955-56

Conditions: ALASKA

Overlay Date: –

Pavement Type: ASPHALT

Traffic Area: C

Feature Dimensions: 200 FT X 2000 FT

Primary Aircraft: –

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
ASPHALT CONCRETE	4 IN.	
CRUSHED GRAVEL	6 IN.	CBR 80
GRAVEL	20 IN.	COMPACTION 100%
GRAVEL	42 IN.	COMPACTION 95%
P.C.C. SLAB	6 IN.	

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	800 FT^2	0.2
08	LOW	32,000 FT	8.0
08	MED.	920 FT	0.23

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1955-56
Overlay Date: -
Traffic Area: B
Primary Aircraft: T37-T38

Environmental: II-B FREEZE-THAW
Conditions: SOIL SEASONALLY WET
Pavement Type: P.C. CONCRETE
Feature Dimensions: 100 FT X 1300 FT
25 FT X 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	9 IN.	FLEX. STRENGTH 650 psi @ 90 DAYS
FILTER COURSE	6 IN.	COMP. TO 95%
SUBGRADE	6 IN.	COMP. TO 90%

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	140 SLABS	70.0
03	MED.	26	12.8
05	MED.	-	100.0
06	LOW	9	4.5
06	HIGH	2	1.0
07	LOW	3	1.5
10	LOW	187	94.0
12	LOW	2	1.0
14	LOW	2	1.0

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1956-57
Overlay Date: -
Traffic Area: B
Primary Aircraft: T 37/T38

Environmental: II-B FREEZE-THAW
Conditions: SOIL SEASONALLY WET
Pavement Type: P.C. CONCRETE
Feature Dimensions: 100 FT X 1000 FT
25 FT X 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	10 IN.	FLEX. STRENGTH 650 PSI
FILTER COURSE	6 IN.	COMP. TO 95%
SUBGRADE	6 IN.	COMP. TO 90%

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	74 SLABS	46.0
03	MED.	48	30.0
05	MED.	-	100.0
06	LOW	5	3.1
10	LOW	160	100.0
14	LOW	2	1.25

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1941-42
Overlay Date: -
Traffic Area: C
Primary Aircraft: T 37

Environmental Conditions: II-B FREEZE-THAW SOIL SEASONALLY WET
Pavement Type: P.C. CONCRETE
Feature Dimensions: 100 FT x 4400 FT 12.5 FT x 20 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	6 IN.	
SANDY-CLAY SELECT MAT'L	8 IN.	

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
02	LOW	38	2.2
02	MED.	9	0.5
03	LOW	283	16.2
03	MED.	114	6.5
04	LOW	18	1.0
04	MED.	3	0.2
05	HIGH	1,752	100.0
06	LOW	88	5.0
06	MED.	3	0.2
07	LOW	18	1.0

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1955-56
Overlay Date: -
Traffic Area: C
Primary Aircraft: T 37/T 38

Environmental Conditions: II-B FREEZE-THAW SOIL SEASONALLY WET
Pavement Type: ASPHALT
Feature Dimensions: 100 FT X 4900 FT

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C. SURFACE	1½ IN.	
A.C. BINDER	1½ IN.	
BASE	6 IN.	COMP. TO 100%
SUBBASE	7 IN.	COMP. TO 100%
SUBBASE	3 IN.	COMP. TO 95%
SUBGRADE	6 IN.	COMP. TO 95%

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	203,454 FT²	41.52
03	MED.	69 FT²	0.02
08	LOW	28,916 FT	6.0
08	MED.	507 FT	0.1

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
10	LOW	96 SLABS	5.5
12	LOW	23	1.3
13	LOW	181	10.3
14	LOW	29	1.7
15	LOW	15	0.8
15	MED.	3	0.2

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY

Environmental: III-A LOW TEMP.

Construction Date: 1958

Conditions: SOIL DRY ALL YEAR

Overlay Date: -

Pavement Type: P.C. CONCRETE

Traffic Area: A

Feature Dimensions: 100 FT X 500 FT
25 FT X 25 FT SLABS

Primary Aircraft: B-52

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	23 IN.	FLEX. STR. 665 PSI
GRAVEL BASE	24 IN.	K = 140 PCI
CLAY SUBGRADE		FROST GROUP - F-3

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
05	LOW	40 SLABS	50.0
06	LOW	10	12.5
06	MED.	1	1.25
10	LOW	1	1.25
13	LOW	6	7.5
14	LOW	1	1.25
14	HIGH	2	2.5
15	LOW	1	1.25
15	MED.	1	1.25

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY

Environmental: III-A LOW TEMP.

Construction Date: 1960 17 IN. RPCC

Conditions: SOIL DRY ALL YEAR

Overlay Date: 1969

Pavement Type: ASPHALT

Traffic Area: C

Feature Dimensions: 75 FT x 525 FT

Primary Aircraft: B-52, KC-135

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C. 2 IN. AVERAGE THICKNESS		
R.P.C.C.	17 IN.	FLEX. STR. 750 PSI
GRAVEL	18 IN.	K = 160 PCI
CLAY		F-3 SOIL

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
05	LOW	19 FT^2	0.05
07	LOW	1,183 FT	3.0
07	MED.	778 FT	1.98
08	LOW	133 FT	0.34
12	LOW	190 FT^2	0.48

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1956
Overlay Date: –
Traffic Area: B
Primary Aircraft: B-52, KC/135

Environmental: III-A LOW TEMP.
Conditions: SOIL DRY ALL YEAR
Pavement Type: P.C. CONCRETE
Feature Dimensions: 100 FT X 500 FT; 25 FT X 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	19 IN.	FLEX. STR. = 650 PSI
GRAVEL FILTER COURSE	4 IN.	K=60 PCI
CLAY		F-3 SOIL

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
05	LOW	– SLABS	36.0
05	MED.	–	64.0
06	LOW	1	1.3
06	MED.	1	1.3
10	LOW	20	26.3
13	LOW	2	2.6
14	LOW	1	1.3
14	MED.	2	2.6
15	LOW	4	5.3
15	MED.	2	2.6
15	HIGH	1	1.3

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1956
Overlay Date: 1966
Traffic Area: C
Primary Aircraft: B-52, KC-135

Environmental: III-A LOW TEMP.
Conditions: SOIL DRY ALL YEAR
Pavement Type: ASPHALT
Feature Dimensions: 50 FT x 2000 FT

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C.	8 IN.	
P.C.C.	17 IN.	FLEX. STR. 650 PSI
GRAVEL FILTER COURSE	4 IN.	K=60 PCI
CLAY		F-3 SOIL

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
07	LOW	5900 FT	5.9
07	MED.	3,914 FT	3.9
07	HIGH	114 FT	0.11
05	LOW	46 FT²	0.05
08	LOW	375 FT	0.37
08	MED.	240 FT	0.24
10	LOW	411 FT²	0.40
13	LOW	1,537 FT²	1.53

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1943
Overlay Date: 1960
Traffic Area: C
Primary Aircraft: C-141
Environmental: I-B FREEZE-THAW
Conditions: SOIL WET ALL YEAR
Pavement Type: ASPHALT
Feature Dimensions: 100 FT x 4800 FT

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C. SURFACE	1.25 IN.	
A.C. BINDER	1.5 IN.	
DRY BOUND MACADAM	10 IN.	
BASE	8 IN.	CBR 80
SAND		CBR 40
CLAYEY SAND		CBR 10

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	28,702 FT²	5.98
01	MED.	70,944 FT²	14.78
03	LOW	201,060 FT²	41.89
03	MED.	32,460 FT²	6.75
03	HIGH	11,500 FT²	2.40
08	LOW	605 FT	0.13
08	MED.	538 FT	0.11
10	LOW	2,880 FT²	0.60
12	LOW	72,000 FT²	18.00
13	LOW	7,776 FT²	1.62
13	MED.	12,480 FT²	2.60

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1957
Overlay Date: -
Traffic Area: A
Primary Aircraft: B-52, KC-135
Environmental: III-A LOW TEMP.
Conditions: SOIL DRY ALL YEAR
Pavement Type: R.P.C. CONCRETE
Feature Dimensions: 100 FT x 500 FT
25 FT x 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
R.P.C.C.	22 IN.	FLEX. STR. = 650 PSI
GRAVEL FILTER COURSE	4 IN.	K = 60 PCI
CLAY		F-3 SOIL GROUP

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
05	LOW	-	100.0
06	LOW	1	1.25
06	MED.	2	2.5
10	LOW	51	63.75
13	LOW	5	6.25
14	LOW	1	1.25
15	LOW	1	1.25
15	MED.	1	1.25

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Environmental: I-B FREEZE-THAW
Construction Date: 1943
Conditions: SOIL WET ALL YEAR
Overlay Date: 1965
Pavement Type: ASPHALT
Traffic Area: C
Feature Dimensions: 100 FT x 5825 FT
Primary Aircraft: C-141

PAVEMENT STRUCTURE	AVAILABLE PROPERTIES
A.C. SURFACE	
A.C. BINDER	
BASE	CBR'S 66
BASE	100+
SUBBASE	32
A.C. [illegible]	58
SUBGRADE - SILTY SAND	38

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	71,456 FT^2	12.7
01	MED.	26,342 FT^2	4.9
08	LOW	6,731 FT	1.2
08	MED.	5,858 FT	1.0

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Environmental: I-B FREEZE-THAW
Construction Date: 1954
Conditions: SOIL WET ALL YEAR
Overlay Date: 1964
Pavement Type: ASPHALT
Traffic Area: C
Feature Dimensions: 100 FT x 1900 FT
Primary Aircraft: C-141, B-747

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C. SURFACE	1½ IN.	
A.C. BINDER	1½ IN.	
MACADAM	6 IN.	CBR'S 100
GW BASE	6 IN.	100+
SELECT MATERIAL	8 IN.	28
SUBGRADE-SILTY SAND		50

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	114,360 FT^2	6.02
01	MED.	5,283 FT^2	2.7
08	LOW	1,335 FT^2	0.7
08	MED.	596 FT	0.3
08	HIGH	292 FT	0.02
10	LOW	1,601 FT^2	0.8
12	LOW	87 FT^2	0.05
13	LOW	79 FT^2	0.04

FEATURE MAINTENANCE AND REPAIR
EVALUATION

1. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY

Construction Date: 1954

Overlay Date: -

Traffic Area: A

Primary Aircraft: C-141

Environmental Conditions: I-B FREEZE-THAW SOIL WET ALL YEAR

Pavement Type: CONCRETE

Feature Dimensions: 100 FT X 1000 FT 25 FT X 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	16 IN.	FLEX. STR. = 650 PSI
SELECT MATERIAL	3 IN.	K = 350 PCI
SUBGRADE SILTY SAND		FROST GROUP F-2

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	31 SLABS	15.71
03	MED.	23	11.43
03	HIGH	9	4.28
05	LOW	29	14.29
06	LOW	30	15.0
06	MED.	31	15.71
06	HIGH	6	2.86
07	LOW	29	14.29
07	MED.	10	5.0
10	LOW	191	95.71

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
12	LOW	3	1.43
12	MED.	1	0.71

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY

Construction Date: 1942

Overlay Date: -

Traffic Area: C

Primary Aircraft: DC-9

Environmental: I-A LOW TEMP

Conditions: SOIL WET ALL YEAR

Pavement Type: CONCRETE

Feature Dimensions: 75 FT X 2760 FT; 12.5 FT X 20 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	8 IN.	FLEX. STR. = 700 PSI
GRANULAR MAT'L	6 IN.	K = 200 PCI
SUBGRADE-CLAY (CL)		

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	7 SLABS	0.8
02	MED.	4	0.48
02	HIGH	1	0.12
03	LOW	31	3.7
03	MED.	38	4.6
03	HIGH	11	1.3
04	LOW	17	2.1
04	MED.	8	0.97
04	HIGH	1	0.12
05	HIGH	-	100.0

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
06	LOW	54 SLABS	6.5
06	MED.	9	1.1
06	HIGH	2	0.24
07	LOW	18	2.2
07	MED.	5	0.6
11	LOW	24	2.9
11	MED.	8	0.97
12	LOW	2	0.24
12	MED.	1	0.12
13	LOW	10	1.2
14	LOW	68	8.2
14	MED.	4	0.48
14	HIGH	5	0.60
15	LOW	24	2.9
15	MED.	9	1.1
15	HIGH	6	0.72

FEATURE MAINTENANCE AND REPAIR
EVALUATION

1. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1955-56
Overlay Date: -
Traffic Area: B
Primary Aircraft: T37, T38
Environmental Conditions: II-B FREEZE-THAW SOIL SEASONALLY WET
Pavement Type: CONCRETE
Feature Dimensions: 100 FT x 500 FT 25 FT x 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	10 IN.	FLEX. STR. = 670 PSI
SANDY GRAVEL	6 IN.	K = 150 PCI
SILTY CLAY		

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
05	MED.	- SLABS	100.0
03	LOW	20	25.0
03	MED.	4	5.0
10	LOW	80	100.0

FEATURE MAINTENANCE AND REPAIR
EVALUATION

1. FEATURE INFORMATION

Feature Type: PRIMARY RUNWAY
Construction Date: 1956
Overlay Date: -
Traffic Area: B
Primary Aircraft: C-141, C-130
Environmental Conditions: II-A LOW TEMP. SOIL SEASONALLY WET
Pavement Type: ASPHALT
Feature Dimensions: 100 FT x 500 FT

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C.	12 IN.	
SANDY GRAVEL	6 IN.	CBR = 40
SAND	6 IN.	CBR = 15
SILTY CLAY		CBR = 6

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	750 FT²	1.50
01	MED.	750 FT²	1.50
08	LOW	2,800 FT	5.60
08	MED.	600 FT	1.20
10	LOW	850 FT²	1.70

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type:	PRIMARY TAXIWAY	Environmental:	I-C HIGH TEMP.
Construction Date:	1961-62	Conditions:	SOIL WET ALL YEAR
Overlay Date:	-	Pavement Type:	CONCRETE
Traffic Area:	A	Feature Dimensions:	50 FT x 1250 FT 25 FT X 25 FT SLABS
Primary Aircraft:	F-4		

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	16 IN	
SUBGRADE LIME ROCK		K=500 P.C.I.

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	9 SLABS	9.0
02	MED.	2	2.0
03	LOW	8	8.0
03	MED.	3	3.0
03	HIGH	2	2.0
06	LOW	3	3.0
10	LOW	100	100.0
12	LOW	2	2.0
13	LOW	1	1.0

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type:	PRIMARY TAXIWAY	Environmental:	III-C HIGH TEMP.
Construction Date:	1967	Conditions:	SOIL DRY ALL YEAR
Overlay Date:	-	Pavement Type:	ASPHALT
Traffic Area:	B	Feature Dimensions:	75 FT X 5760 FT
Primary Aircraft:	FIGHTERS		

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C.	5 IN.	
SANDY GRAVEL	6 IN.	CBR's 40
GRAVELLY SAND	4 IN.	20
SUBGRADE CLAYEY SILTY SAND		5

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	15093 FT²	3.5
01	MED.	28,306 FT²	6.6
02	LOW	1,685 FT²	0.4
03	LOW	242,980 FT²	56.3
05	LOW	156 FT²	0.04
08	LOW	9,291 FT	2.1
08	MED.	156 FT	0.04
10	LOW	203,085 FT²	4.7
13	LOW	4,978 FT²	1.15
13	MED.	862 FT²	0.2
13	HIGH	1,725 FT²	0.4

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Environmental: III-A LOW TEMP.
Construction Date: 1955-56
Conditions: SOIL DRY ALL YEAR
Overlay Date: –
Pavement Type: ASPHALT
Traffic Area: B
Feature Dimensions: 75 FT X 1820 FT

Primary Aircraft: FIGHTERS/CARGO

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C.	4 IN	
SILTY GRAVEL	6 IN	CBR's 100+
SANDY GRAVEL	24 IN	100+
SILTY SAND	18 IN	20
SUBGRADE SILTY SAND		8

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	4,232 FT²	3.13
01	MED.	2,035 FT²	1.51
02	LOW	139 FT²	44.59
03	LOW	59,928 FT²	0.10
08	LOW	701 FT	0.52
08	MED.	218 FT	0.16
10	LOW	701 FT²	0.52
10	MED.	559 FT²	0.41
13	LOW	186 FT²	0.14

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Environmental: III-A LOW TEMP
Construction Date: 1940
Conditions: SOIL DRY ALL YEAR
Overlay Date: 1969
Pavement Type: ASPHALT
Traffic Area: B
Feature Dimensions: 75 FT X 1920 FT

Primary Aircraft: FIGHTER/CARGO

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C.	2 IN.	
P.C.C.	8 IN.-6 IN.-8 IN.	FLEX. STR. = 650 PSI
SILTY SAND.	9 IN.	K = 150 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
01	LOW	531 FT²	0.37
05	LOW	420 FT²	0.29
07	LOW	9,768 FT	6.78
07	MED.	8,728 FT	6.06
07	HIGH	920 FT	0.64
08	LOW	1,660 FT	1.15
08	MED.	176 FT	0.12
08	HIGH	24 FT	0.02
12	LOW	224 FT²	0.15
13	LOW	1,340 FT²	0.93

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Construction Date: 1940
Overlay Date: 1969
Traffic Area: B
Primary Aircraft: FIGHTERS/CARGO
Environmental: III-A LOW TEMP.
Conditions: SOIL DRY ALL YEAR
Pavement Type: ASPHALT
Feature Dimensions: 75 FT X 2220 FT

PAVEMENT STRUCTURE	AVAILABLE PROPERTIES
A.C. 2 IN.	
P.C.C. 8 IN.-6 IN.-8 IN.	FLEX. STR.=650 PSI
SILTY SAND 9 IN.	K=150 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	821 FT²	0.49
01	MED.	721 FT²	0.43
06	LOW	133 FT²	0.08
07	LOW	7,962 FT	4.78
07	MED.	10,292 FT	6.15
07	HIGH	980 FT	0.59
08	LOW	5,030 FT	3.02
08	MED.	1,943 FT	1.17
08	HIGH.	74 FT	0.04
09	LOW	444 FT²	0.26

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Construction Date: 1971
Overlay Date: -
Traffic Area: A
Primary Aircraft: B-52/KC 135
Environmental: III-A LOW TEMP.
Conditions: SOIL DRY ALL YEAR
Pavement Type: ASPHALT
Feature Dimensions: 75 FT X 1825 FT

PAVEMENT STRUCTURE	AVAILABLE PROPERTIES
A.C. 8 IN.	
CRUSHED LIMESTONE 6 IN.	CBR'S 80
GRAVEL 3 IN.	55
CLAY (CL)	8

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	625 FT²	0.50
01	MED	625 FT²	0.50
08	LOW	3,303 FT	2.60
08	MED	5,921 FT	4.30
08	HIGH	203 FT	0.16
13	LOW	2,031 FT²	1.60

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
12	LOW	2361 FT²	1.42
10	LOW	96 FT²	0.06
13	LOW	481 FT²	0.29
13	MED.	296 FT²	0.18
13	HIGH	24 FT²	0.04
16	LOW	666 FT²	0.40
16	MED.	96 FT²	0.06
16	HIGH	89 FT²	0.05

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Construction Date: 1954
Overlay Date: -
Traffic Area: A
Environmental: I-B FREEZE-THAW
Conditions: SOIL WET ALL YEAR
Pavement Type: ASPHALT
Feature Dimensions: 50 FT x 2130 FT

Primary Aircraft: F-105

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
SAND ASPHALT	1½ IN.	
A.C.	2½ IN.	
MACADAM	4 IN.	CBR's 80
SAND	8 IN.	40
SILT		16
CLAYEY SAND		

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	1,457 FT²	1.39
01	MED.	24,336 FT²	25.12
01	HIGH	36 FT²	0.03
03	LOW	33,768 FT²	32.17
03	MED.	7,228 FT²	6.89
05	LOW	1,199 FT²	1.14
05	MED.	204 FT²	0.19
05	HIGH	271 FT²	0.26
08	MED.	1,680 FT	1.60
10	LOW	929 FT²	0.88

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
10	MED.	3,662 FT²	3.49
10	HIGH	470 FT²	0.45
13	MED.	4,121 FT²	3.94
13	HIGH	2,484 FT²	2.37

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Construction Date: 1955
Overlay Date: -
Traffic Area: A
Environmental: III-A LOW TEMP
Conditions: SOIL DRY ALL YEAR
Pavement Type: ASPHALT
Feature Dimensions: 50 FT x 4200 FT

Primary Aircraft: B-52/KC-135

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
A.C.	4 IN.	
CRUSHED LIMESTONE	12 IN.	CBR's 80
GRAVEL	28 IN.	80
CLAY (CL)		6

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
01	LOW	160 FT²	0.36
01	MED.	19,050 FT²	42.30
01	HIGH	3,030 FT²	6.70
05	HIGH	9 FT²	0.02
10	LOW	48 FT²	0.11
12	LOW	108 FT²	0.24
12	MED.	60 FT²	0.13
13	LOW	5,726 FT²	12.70
13	MED.	780 FT²	1.70
13	HIGH	303 FT²	0.67
16	MED.	72 FT²	0.16

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY

Construction Date: 1952

Overlay Date: -

Traffic Area: A

Primary Aircraft: C-141

Environmental Conditions: I-B FREEZE-THAW SOIL WET ALL YEAR

Pavement Type: CONCRETE

Feature Dimensions: 75FT X 3950FT 25FT X 25FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	16 IN.	FLEX. STR. = 650 PSI
SAND FILTER	2 IN.	K = 225 PCI
SILTY SAND		

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	2 SLABS	0.56
02	HIGH	2	0.56
03	LOW	54	12.78
03	MED.	136	32.78
03	HIGH	37	8.89
04	LOW	7	1.67
05	LOW	-	10.00
05	MED.	-	20.00
05	HIGH	-	10.00
06	LOW	30	7.22

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
06	MED.	69 SLABS	16.67
06	HIGH	21	5.0
07	LOW	5	1.11
07	MED.	12	2.78
10	LOW	357	88.11
11	LOW	9	2.02
11	MED.	14	3.33
12	LOW	5	1.11
13	LOW	2	0.56
14	LOW	9	2.02
14	HIGH	5	1.11
15	LOW	5	1.11
15	MED.	2	0.56
15	HIGH	5	1.11

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Construction Date: 1954
Overlay Date: –
Traffic Area: A
Primary Aircraft: F-105

Environmental Conditions: I-B FREEZE-THAW SOIL WET ALL YEAR
Pavement Type: CONCRETE
Feature Dimensions: 37 1/2 FT x 1560 FT
12 1/2 FT x 20 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	7 IN.	FLEX. STR. = 650 PSI
SUBGRADE		K = 400 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	11 SLABS	1.58
03	LOW	70	10.32
03	MED.	41	6.35
03	HIGH	22	3.17
05	LOW	–	100.00
07	LOW	4	0.79
06	LOW	11	1.59
06	MED.	11	1.59
10	LOW	41	6.35
11	LOW	4	0.79

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY TAXIWAY
Construction Date: 1955
Overlay Date: –
Traffic Area: B
Primary Aircraft: CARGO

Environmental: LOW TEMP.
Conditions: ALASKA
Pavement Type: CONCRETE
Feature Dimensions: 50 FT x 1250 FT
25 FT x 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	11 IN.	FLEX. STR. = 600 PSI
GRAVEL	22 IN.	K = 250 PCI
SUBGRADE		

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	5 SLABS	5.00
03	MED.	15	15.00
03	HIGH	5	5.00
12	LOW	30	30.00
12	MED.	35	35.00
12	HIGH	10	10.00

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
14	LOW	4 SLABS	0.79
15	LOW	11	1.59
15	MED.	26	3.91
15	HIGH	11	1.59

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON

Construction Date: 1958

Overlay Date: –

Traffic Area: B

Primary Aircraft: FIGHTER

Environmental Conditions: III-A LOW TEMP. SOIL DRY ALL YEAR

Pavement Type: CONCRETE

Feature Dimensions: 665 FT x 1096 FT, 25 FT x 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	14 IN.	FLEX. STR. = 650 PSI
SILTY-SANDY GRAVEL	21 IN.	K: 500 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	106 SLABS	8.00
03	MED.	42	3.20
04	LOW	13	1.00
05	LOW	–	39.70
06	LOW	52	3.90
06	MED.	3	0.23
06	HIGH	6	0.46
07	LOW	3	0.23
10	LOW	411	31.10
10	MED.	3	0.23

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
13	LOW	97 SLABS	7.30
14	LOW	23	1.70
14	MED.	3	0.23
15	LOW	30	2.30
15	MED.	9	0.64
15	HIGH	3	0.23

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON — Environmental Conditions: III-A LOW TEMP. SOIL DRY ALL YEAR

Construction Date: 1962 — Pavement Type: CONCRETE

Overlay Date: -

Traffic Area: B — Feature Dimensions: 471 FT x 600 FT, 25 FT x 25 FT SLABS

Primary Aircraft: CARGO/C-130

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	13 IN.	FLEX. STR. = 700 PSI
SANDY GRAVEL	22 IN.	K = 225 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	63 SLABS	13.10
03	MED.	15	3.10
03	HIGH	12	2.50
05	LOW	–	14.30
05	MED.	–	74.20
06	LOW	5	1.00
06	MED.	7	1.40
07	LOW	7	1.40
07	MED.	2	0.40
08	LOW	2	0.40

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
10	LOW	116 SLABS	24.20
10	MED.	4	0.80
11	LOW	10	2.10
12	HIGH	2	0.40
13	LOW	27	5.60
14	LOW	7	1.40
14	MED.	3	0.60
15	LOW	10	2.10
15	MED.	8	1.20
15	HIGH	7	1.40

FEATURE MAINTENANCE AND REPAIR EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON

Construction Date: 1956

Overlay Date: -

Traffic Area: C

Primary Aircraft: F-4

Environmental: I-C HIGH TEMP.

Conditions: SOIL WET ALL YEAR

Pavement Type: CONCRETE

Feature Dimensions: 50FT X 2375 FT; 25FT X 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	9 IN.	FLEX. STR. = 600 PSI
SANDY CLAY		K = 330 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
05	LOW	- SLABS	100.0
03	LOW	157	34.40
03	MED.	14	3.1
03	HIGH	3	0.60
04	LOW	37	8.10
04	MED.	69	15.10
04	HIGH	19	4.20
06	LOW	64	14.00
06	MED.	16	3.50
06	HIGH	9	0.88

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
07	LOW	12 SLABS	2.60
07	MED.	3	0.60
10	LOW	5	1.10
12	LOW	2	0.44
12	MED.	2	0.44
13	LOW	185	40.60
14	LOW	7	1.50
14	MED.	7	1.50
15	LOW	49	10.70
15	MED.	12	2.60
15	HIGH	2	0.44

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON
Construction Date: 1956
Overlay Date: –
Traffic Area: B
Primary Aircraft: C5A/C141

Environmental Conditions: I-B FREEZE-THAW SOIL WET ALL YEAR
Pavement Type: CONCRETE
Feature Dimensions: 75 FT x 360 FT 12½ FT x 25 FT SLABS

PAVEMENT STRUCTURE	AVAILABLE PROPERTIES
P.C.C. 9 IN.	FLEX. STR. = 670 PSI
CRUSHED STONE 6 IN.	K = 125 PCI
CLAYEY SILT	

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	3 SLABS	4.20
02	MED.	6	8.40
03	LOW	4	5.50
03	MED.	6	8.40
04	MED.	3	4.20
06	MED.	9	12.50
10	LOW	10	13.90
14	LOW	6	8.40
14	MED.	3	4.20
15	MED.	3	4.20

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON
Construction Date: 1942
Overlay Date: –
Traffic Area: –
Primary Aircraft: T37/T39

Environmental Conditions: III-B FREEZE-THAW SOIL DRY ALL YEAR
Pavement Type: CONCRETE
Feature Dimensions: 200 FT x 300 FT 12½ FT x 15 FT SLABS

PAVEMENT STRUCTURE	AVAILABLE PROPERTIES
P.C.C. 6 IN.	FLEX. STR. = 650 PSI
SUBGRADE CLAYEY SAND	K = 200 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
02	LOW	96 SLABS	30.00
02	HIGH	16	5.00
03	LOW	48	15.00
03	MED.	32	10.00
06	LOW	128	40.00
11	LOW	32	10.00
12	LOW	32	10.00
14	LOW	48	15.00

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON
Construction Date: 1950
Overlay Date: –
Traffic Area: B
Primary Aircraft: C-141

Environmental Conditions: II-C HIGH TEMP. SOIL SEASONALLY WET
Pavement Type: CONCRETE
Feature Dimensions: 200 FT X 400 FT, 25 FT X 25 FT SLABS

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	11 IN.	FLEX. STR = 650 PSI
CLAYEY SILT		K = 150 PCI

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
03	LOW	20 SLABS	17.00
03	MED.	47	39.00
03	HIGH	13	11.00
06	LOW	20	17.00
06	MED.	47	39.00
07	MED.	13	11.00
10	LOW	94	78.00
12	LOW	7	5.50
14	LOW	7	5.50
05	HIGH	-	100.00

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON
Construction Date: 1964
Overlay Date: –
Traffic Area: B
Primary Aircraft: C9A-T39

Environmental Conditions: I-B FREEZE-THAW SOIL WET ALL YEAR
Pavement Type: TAR RUBBER
Feature Dimensions: 300 FT X 1000 FT

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
TAR RUBBER	2 IN.	
CEMENT STABIL. MAT'L.	6 IN.	CBR's 100+
SANDY GRAVEL	6 IN.	20
SAND	12 IN.	12
SILTY CLAY		6

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY
03	LOW	247,500 FT²	75.00
03	MED.	33,000 FT²	10.00
09	LOW	6,600 FT²	2.00

FEATURE MAINTENANCE AND REPAIR
EVALUATION

I. FEATURE INFORMATION

Feature Type: PRIMARY APRON

Environmental: III-A LOW.TEMP.

Construction Date: 1974

Conditions: SOIL DRY ALL YEAR

Overlay Date: -

Pavement Type: CONCRETE

Traffic Area: A

Feature Dimensions: 750 FT X 225 FT
25 FT X 25 FT SLABS

Primary Aircraft: C130/C5-A

PAVEMENT STRUCTURE		AVAILABLE PROPERTIES
P.C.C.	13 IN.	FLEX. STR. 650 PSI
SANDY GRAVEL	22 IN.	K=350 PCI
SILTY SAND		

DISTRESS SUMMARY
(Average Quantity Over Entire Feature)

DISTRESS TYPE	SEVERITY	QUANTITY	DENSITY %
14	LOW	18 SLABS	6.67
15	LOW	18	6.67
10	LOW	15	5.56

APPENDIX H

ECONOMIC ANALYSIS CONSIDERING PERFORMANCE

PERFORMANCE AND PRESENT COST PROCEDURE

This procedure is similar to the economic analysis procedure described in Volume III, with the addition that pavement performance (PCI history over time) is taken into consideration. Instead of comparing alternatives based on present worth alone, alternatives are compared based on weighted performance per $/sy (i.e., how much performance is obtained for each dollar spent). The quantity ($/sy) is determined by dividing the present worth by the total area of the pavement feature in square yards. The weighted performance is obtained by calculating the area under the PCI versus time curve for the analysis period and weighting this area based on the importance of the pavement feature, (e.g., primary runway, secondary runway). The weighted performance for any given M&R alternative can be calculated as illustrated in Figure H-1, using the following equation.

$$\text{Weighted performance} = \sum_{i=1}^{p} Ai \cdot Wi \qquad \text{(H-1)}$$

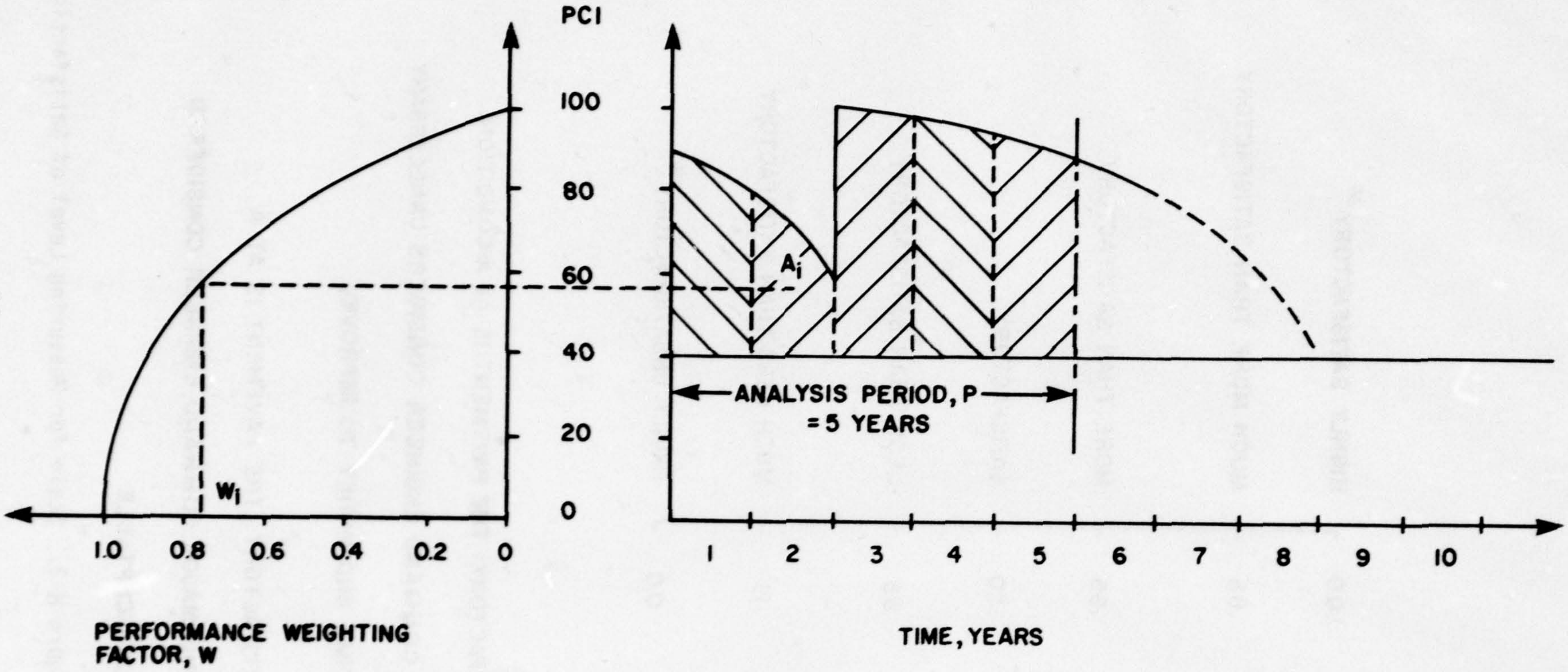
where P = analysis period in years,

Ai = area between the PCI curve and the minimum acceptable PCI for year i, and

Wi = performance weighting factor for year i.

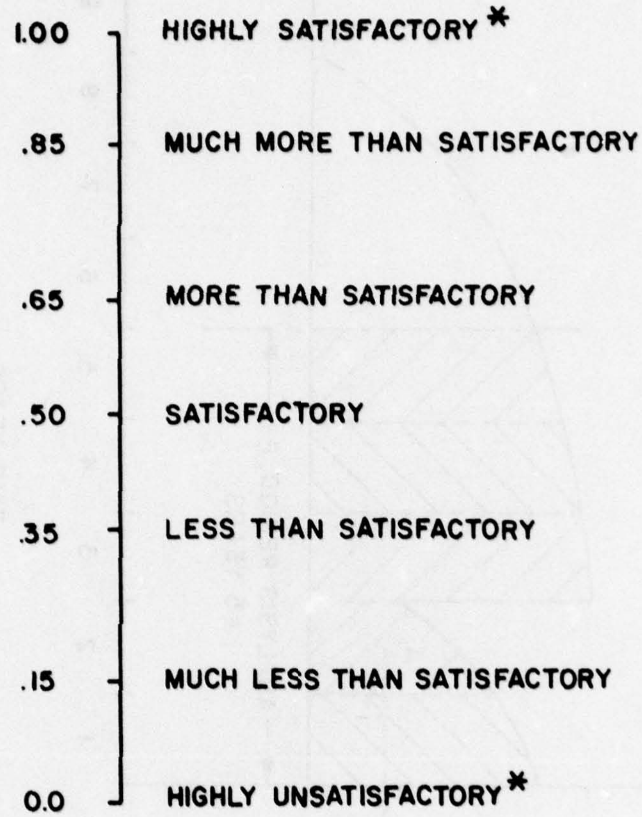
Use of this procedure requires the establishment of the performance weighting factors for different airfield pavement features. The factors were developed during a workshop attended by 10 experienced pavement engineers, including four Air Force major command engineers. Questionnaires were designed and then administered to the engineers during the workshop. A scale from 0 to 1.0 (Figure H-2) was used to determine the level of satisfaction of the engineers for six types of pavement features at seven different levels of pavement condition. The pavement features considered were primary and secondary runways, taxiways, and aprons. The different pavement conditions corresponded to the condition rating on the PCI scale, i.e., failed, very poor, fair, good, very good, and excellent. The complete questionnaire is given in Appendix I. For each pavement type and condition, the average level of satisfaction of the 10 engineers was determined.

The performance weighting factors were then determined as 1.0 minus the levels of satisfaction. Figures H-3, H-4, and H-5 show the levels of satisfaction and performance weighting factors versus the PCI for runways, taxiways, and aprons. It can be seen that, for any given PCI value, the level of satisfaction for a primary pavement is lower than the factor for secondary pavements.



$$\text{WEIGHTED PERFORMANCE} = \sum_{i=1}^{P=5} A_i \cdot W_i$$

Figure H-1. Illustration of Calculation of Weighted Performance for an M&R Alternative



*HIGHLY SATISFACTORY: THE PAVEMENT IS AT A CONDITION THE MAJOR COMMAND ENGINEER CONSIDERS UNNECESSARY TO SPEND TIME AND MONEY TO IMPROVE.

*HIGHLY UNSATISFACTORY: THE PAVEMENT IS AT A CONDITION THE MAJOR COMMAND ENGINEER CONSIDERED DEFINITELY UNACCEPTABLE

Figure H-2. Scale for Measuring Level of Satisfaction

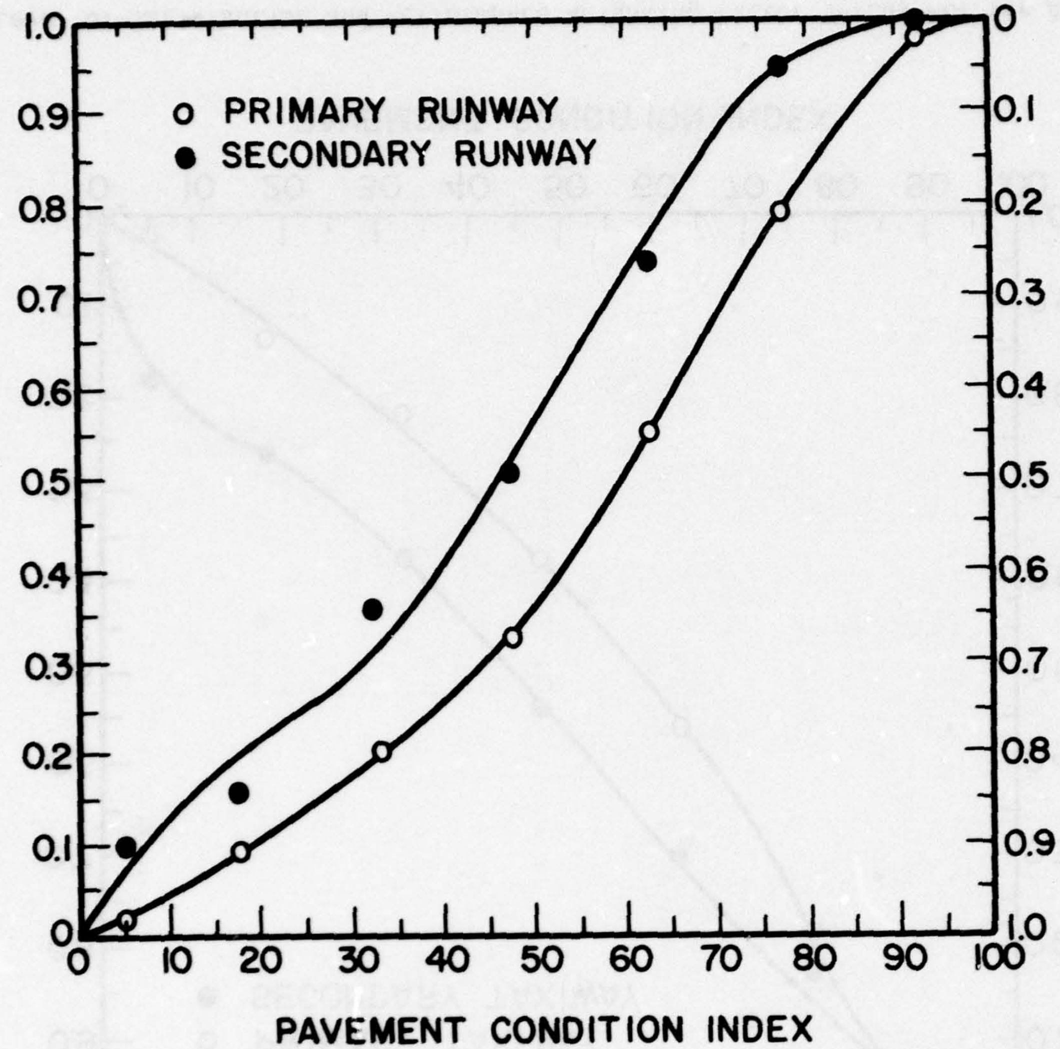


Figure H-3. Level of Satisfaction and Performance Weighting Factor Versus PCI for Runways

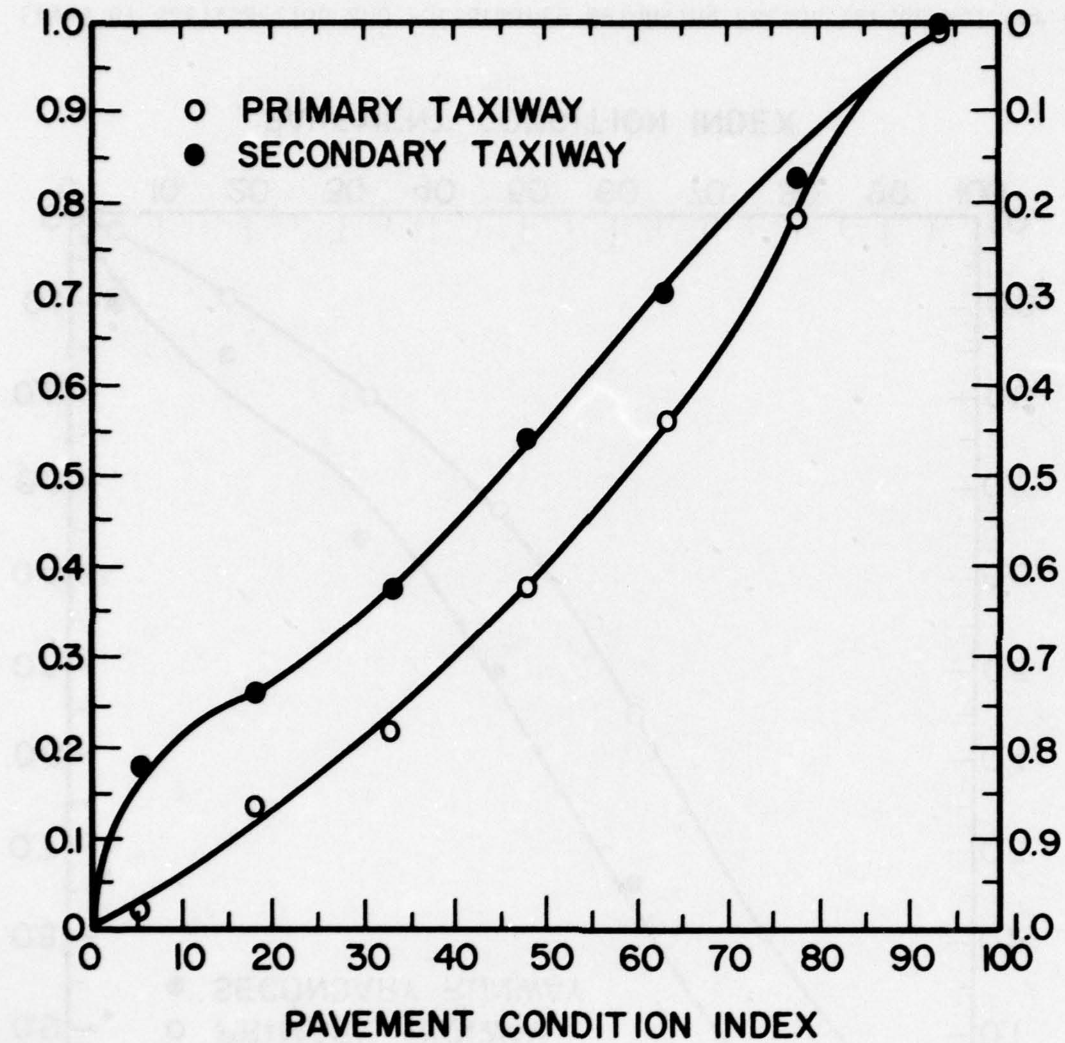


Figure H-4. Level of Satisfaction and Performance Weighting Factor Versus PCI for Air Taxiways

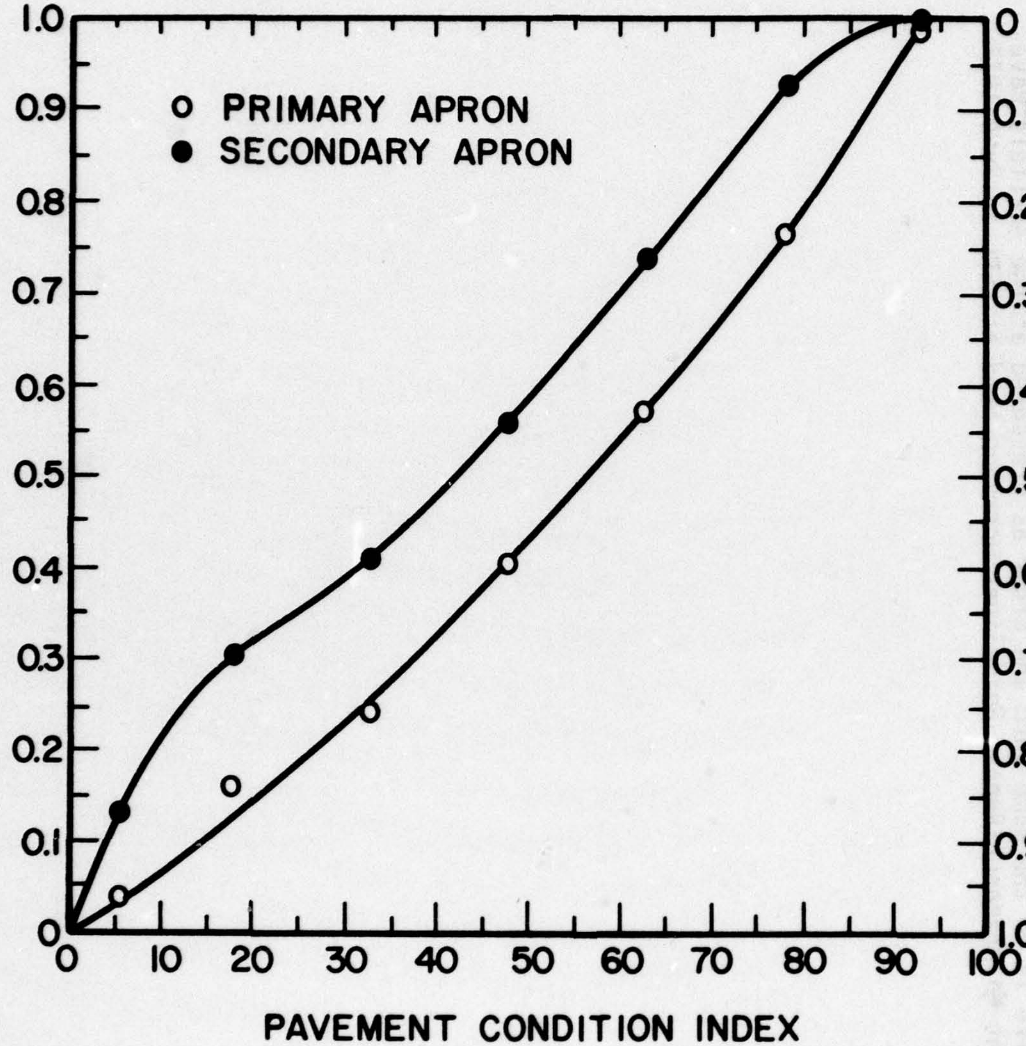


Figure H-5. Level of Satisfaction and Performance Weighting Factor Versus PCI for Aprons

APPENDIX I

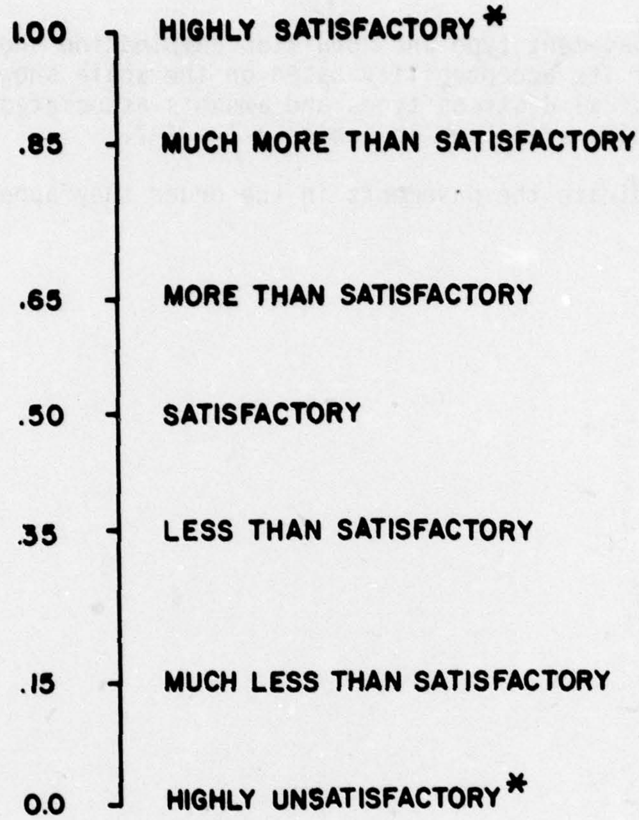
WEIGHTED PERFORMANCE QUESTIONNAIRE

This appendix shows the questionnaires used to obtain the performance weighting factors for use in the economic analysis. The questionnaire is in the same form and order as presented at the Airfield Pavement Maintenance-Repair Guidelines Workshop held at CERL in June 1977.

QUESTIONNAIRE ON PERFORMANCE WEIGHTING FACTORS

For each pavement type and condition combination shown, please give your opinion of its acceptability based on the scale shown in Figure I-1. Examples of typical distress types and amounts associated with a given pavement condition are shown in Tables I-1 - I-7.

Please indicate the pavements in the order they appear in the questionnaire.



*HIGHLY SATISFACTORY: THE PAVEMENT IS AT A CONDITION THE MAJOR COMMAND ENGINEER CONSIDERS UNNECESSARY TO SPEND TIME AND MONEY TO IMPROVE.

*HIGHLY UNSATISFACTORY: THE PAVEMENT IS AT A CONDITION THE MAJOR COMMAND ENGINEER CONSIDERED DEFINITELY UNACCEPTABLE

Figure I-1. Level of Satisfaction Scale

TABLE I-1. EXAMPLES OF EXCELLENT PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS.

Crazing	:	25% L
Joint Filler	:	M

Crazing	:	5% L
Joint Spall	:	5% L
Joint Filler	:	L

ASPHALT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA.

Longitudinal and Transverse Crack	:	1.8% L

Longitudinal and Transverse Crack	:	1.5% L
Weathering	:	7% L

TABLE I-2. EXAMPLES OF VERY GOOD PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS.

"D" Cracking	: 83% L
Small Patch	: 8% L
Corner Spall	: 8% L
Joint Filler	: M

Longitudinal and Transverse Crack	: 5% L
Small Patch	: 5% M
Crazing	: 30 % L
Joint Spall	: 5% L
Joint Filler	: M

ASPHALT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA.

Depression	: 0.3% L
Joint Reflection Crack	: 11% L
Longitudinal and Transverse Crack	: 0.3% L

Alligator Crack	: 1.4% L
Longitudinal and Transverse Crack	: 1.1% L

TABLE I-3. EXAMPLES OF GOOD PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS.

Longitudinal and Transverse Crack	:	25% L, 5% M
Crazing	:	100% L
Joint Filler	:	M

Longitudinal and Transverse Crack	:	12.5% L, 12.5% M
Crazing	:	50% L
Corner Spall	:	6.25% L
Joint Spall	:	6.25 L
Joint Filler	:	M

ASPAHLT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA.

Joint Reflection Crack	:	4% L, 3.5% M, 0.5% H
Longitudinal and Transverse Crack	:	1.3% L
Rutting	:	5% L

Block Crack	:	100% L

TABLE I-4. EXAMPLES OF <u>FAIR</u> PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS.

Longitudinal and Transverse Crack	:	75% L, 25% M
Crazing	:	85% L
Joint Filler	:	M
Small Patch	:	10% L

Longitudinal and Transverse Crack	:	10 % L, 20% M
Corner Spall	:	5% M
Small Patch	:	5% M, 5% H
Crazing	:	95% L
Shrinkage Crack	:	5% L
Joint Filler	:	L

ASPHALT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA.

Alligator Crack	:	8.5% L, 1 % M
Longitudinal and Transverse Crack	:	0.5% L

Alligator Crack	:	7.4% L
Longitudinal and Transverse Crack	:	1.5% L
Rutting	:	4.8% M

TABLE I-5. EXAMPLES OF <u>POOR</u> PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS.

Longitudinal and Transverse Crack	:	5.5% L, 44.4% M
Small Patch	:	28% L, 17% M
Long Patch	:	17% M
Crazing and Scaling	:	94% L, 6% M
Joint Filler	:	M

ASPHALT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA.

Alligator Crack	:	12% L, 2% M
Rutting	:	8% L

TABLE I-6. EXAMPLES OF VERY POOR PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS.

Longitudinal and Transverse Crack	: 17% L, 39% M, 11% H
"D" Crack	: 11%L
Small Patch	: 17% L, 39% M
Long Patch	: 11% M
Crazing	: 78% L
Divided Slab	: 5.5% L
Joint Spall	: 5.5% L
Joint Filler	: H

Longitudinal and Transverse Crack	: 37.5% L, 16.7% M, 12.5% H
"D" Crack	: 16.7%L, 20.8% M
Small Patch	: 20.8% L, 8.3% M
Crazing	: 4.16% L
Divided Slab	: 4.16% L, 4.16% M
Shrinkage Crack	: 33.3% L
Corner Spall	: 8.3% L, 8.3% M
Joint Spall	: 12.5% L, 8.3% M
Joint Filler	: L

ASPHALT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA

Alligator Crack	: 6% L, 19.6% M
Rutting	: 4% L, 3.6% M
Block Crack	: 6% L, 20% M

Alligator Crack	: 52% M, 0.9% H
Weathering	: 18% M

TABLE I-7. EXAMPLES OF FAILED PAVEMENT CONDITION

CONCRETE SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT SLABS

Longitudinal and Transverse Crack	:	5% L, 15% M, 5% H
Divided Slab	:	35% L, 30% M, 10% H

ASPHALT OR TAR SURFACED PAVEMENT: DISTRESS QUANTITY IS IN PERCENT AREA

Alligator Crack	:	40% M, 10% H
Rutting	:	16% L, 6% M

For the following pavement uses and conditions, indicate your Level of Satisfaction with the situation:

Pavement Use	Condition	Level of Satisfaction
Primary Taxiway	Failed	
Secondary Apron	Very Good	
Primary Apron	Excellent	
Secondary Taxiway	Very Good	
Secondary Apron	Very Poor	
Secondary Runway	Poor	
Secondary Apron	Poor	
Secondary Runway	Very Good	
Primary Apron	Fair	
Primary Runway	Fair	
Secondary Taxiway	Failed	
Primary Runway	Failed	
Secondary Runway	Failed	
Primary Apron	Failed	
Primary Runway	Poor	
Primary Apron	Very Poor	
Primary Apron	Good	
Secondary Taxiway	Poor	
Primary Taxiway	Fair	
Primary Taxiway	Excellent	
Secondary Runway	Fair	
Secondary Apron	Excellent	

Pavement Use	Condition	Level of Satisfaction
Secondary Apron	Fair	
Secondary Runway	Very Poor	
Primary Apron	Poor	
Primary Runway	Excellent	
Secondary Taxiway	Fair	
Primary Taxiway	Very Poor	
Primary Taxiway	Good	
Primary Runway	Very Poor	
Primary Taxiway	Very Good	
Secondary Apron	Good	
Primary Runway	Very Good	
Secondary Runway	Good	
Primary Taxiway	Poor	
Secondary Taxiway	Very Poor	
Secondary Apron	Failed	
Primary Runway	Good	
Primary Apron	Very Good	
Secondary Runway	Excellent	
Secondary Taxiway	Excellent	
Secondary Taxiway	Good	

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INITIAL DISTRIBUTION

Hq USAF/PRE	1
Hq USAF/PREES	1
Hq USAF/PREM	1
Hq AFSC/DEM	5
Hq TAC/DEMM	26
Hq SAC/DEMM	10
Hq AFLC/DEMM	9
Hq ADCOM/DEMM	15
ADTC/DEE	1
AFATL/DLODL	2
Hq ATC/DEMM	20
Hq DA/DAEN-FED-P	2
USAE/WES	10
CERL/FOM	50
Hq AU/DE	2
Hq AAC/DEEE	5
AUL/LSE 71-249	1
AFIT/DES	1
AFIT/Tech Lib	1
Hq USAFE/DEMO	30
Hq PACAF/DEMM	16
Hq USAFA/DFDC	2
ASD/DEE	1
DDC/AF	2
Hq MAC/DEMU	25
Hq AFSC/DEE	2
Hq AFRES/DEMM	12
ANG/FSC/DE	8
Univ of New Mexico/CERF	1
375 ABG/DEE	1
CEL/USNCBC	1
AFCEC/DEM	15
Det 1 ADTC/PRT	1
ARD-430/FAA	5
NAVFAC	5
ADTC/DEEE	1
AFIT/DE	3
Hq USAF/RDPQ	1
Det 1 ADTC/CNG	25
Hq SHAPE/Logistics & Armament Div/ Airfields Section	5
Det 1 ADTC/DAY	1

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